

BRIDGES  
ITALY - CHINA

4, 2025

THE VALUE OF SCIENCE AND TECHNOLOGY  
IN ADDRESSING THE GREAT CHALLENGES OF OUR TIME

edited by

Francesco De Matteis and Diana Angela Palma

with the collaboration of

Nataschia Conforti, Michaela Riccio, Emanuele Scarpato, Diletta Taverni



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*Monographic Series by the Department of Social sciences and humanities,  
cultural heritage of the National Research Council*



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**THE VALUE OF SCIENCE AND TECHNOLOGY  
IN ADDRESSING THE GREAT CHALLENGES OF OUR TIME**

Inaugural Session and Thematic Forums Proceedings

**Italy-China Science, Technology and Innovation Week  
13<sup>th</sup> edition**

Promoted by



**中华人民共和国科学技术部**  
Ministry of Science and Technology of the People's Republic of China

Realized by



**北京市科学技术委员会、  
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*This volume presents the proceedings of the inaugural session and thematic forums held in Naples and Venice from November 26<sup>th</sup> to 28<sup>th</sup>, 2024, on the occasion of the 13<sup>th</sup> edition of the Italy-China Science, Technology and Innovation Week. The event is part of the bilateral programme of scientific and technological cooperation between Italy and China. It was jointly promoted by the governments of the two countries through the Ministry of Universities and Research of the Italian Republic and the Ministry of Science and Technology of the People's Republic of China. The programme was coordinated, on the Italian side, by the Idis Foundation – Città della Scienza, in collaboration with the National Research Council of Italy, and, on the Chinese side, by the Beijing Municipal Science & Technology Commission and the Administrative Commission of Zhongguancun Science Park. The 13<sup>th</sup> Edition also benefited from the cooperation of Ca' Foscari University of Venice (Italy) and the International Technology Transfer Network (China). The thematic forums brought together scholars, researchers and experts from Italian and Chinese universities and research centers, who engaged in a rich and wide-ranging exchange of views, driven by interdisciplinary approaches and sustained dialogue between the two scientific communities.*

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**PREMISE**  
**COOPERATION BETWEEN ITALY AND CHINA. A SHARED**  
**RESPONSIBILITY IN THE WAKE OF A THOUSAND-YEAR-OLD TRADITION**

Cooperation is an implicit dimension of intellectual work. Since ancient times, the inherent tendency of intellectual work to look beyond what is already known has resulted in the overcoming of geographical, political, cultural and linguistic barriers, and in the different historical periods it has found forms adapted to the different contexts.

Today, in an increasingly globalized world, despite the right and opportune persistence of cultural specificities and even different visions on the ways of organizing social life, cooperation between peoples is confirmed as a common value and, even more than in the past, as a necessity to be accomplished. The challenges humanity is facing have, in fact, a global dimension and there is a shared awareness that only a common and coordinated commitment can make it possible to respond to these challenges effectively.

Relations between the Western world and China have a history that has its roots in antiquity, and as early as the 2<sup>nd</sup> century BC, with the opening of the *Silk Road*, diplomatic relations between China and the Roman Empire were initiated.

The Italians have been the main protagonists of the encounter between European and Chinese culture from the time of Marco Polo's voyages to the 18<sup>th</sup> century<sup>1</sup> onwards, and even today our country continues to play an essential role in spreading knowledge of Chinese civilization in Europe and European civilization in China, drawing inspiration from the spirit that originally animated the *Silk Road* and which was based on the concepts of peace and cooperation, openness and inclusion, mutual learning and mutual benefit.

The fact that the Italian Government has given to the Fondazione Idis-Città della Scienza the role of coordinating the most important event in which the meeting between Italy and China takes place with reference to the prospects opened up by developments in the cultural and scientific spheres is, of course, a source of pride for the Foundation but it is, at the same time, recognition of a responsibility that must be exercised in keeping with the values that our entire country and the city of Naples express.

Placing principles such as solidarity, cooperation and responsibility at the center of the processes of scientific and technological innovation obliges man to design forms of social evolution that do not obscure the *humanitas* that permeates the humanistic culture of which Italy - with Naples often playing a leading role - has become the promoter throughout the world. Starting from the *Circolo degli Scipioni*, Italy has tried to design, through practice

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<sup>1</sup> MENEGATTI 2005; BERTUCCIOLI, MASINI 1996; MENEGUZZI ROSTAGNI 2012.

and thought, a modernity in which attention to man and the dynamics of history, as also affirmed by Pope Francesco, “contributes to a vision of the world that is opposed to the individualist [...] because it is based on the interconnection between people and has the common good as its goal”<sup>2</sup>.

Cooperation is therefore not to be understood as a neutral or merely technical space, but as a sphere of authentic commitment, where the relationship with the other becomes an ethical opportunity and shared responsibility.

Today, everyone – by which is meant the institutions, but also all social actors including individual citizens – is called to play a role in governing the epochal change that the world is experiencing.

It is a change that has two engines acting synergistically: the impetuous developments of science and technology, on one hand, and the processes of globalization, on the other. In similar epochal passages of the past, innovative experiences of thought and of man’s place in the world have flourished, such as the season of Humanism that asserted itself in the transition from the medieval to the modern world. A similar effort of conception and creativity is therefore required which cannot disregard the fact that there is an inextricable connection between the social, economic, demographic and environmental dimensions. This also means that it is necessary to overcome the fragmentation of the disciplines and the opposition between the “different areas of knowledge”, both between the different scientific fields and between these and the human sciences. It is therefore necessary to support the organization of collective research, in every sphere of knowledge, research that is certainly characterized by scientific rigor, but also supported by the experience of solidarity gained by researchers. It is thus a matter of encouraging, by overcoming national barriers, the formation of integrated research groups between researchers and experts representing the world of education, professions, arts, commerce and enterprise. At the heart of this joint effort there are the idea of sustainability in all its possible dimensions, from the environmental to the social and economic, and the idea of responsibility not simply understood as technical responsibility, limited to specific aspects, but as a commitment to a dimension that takes into account the totality of man, the world and the relationship between man and the world.

This is the framework and, at the same time, the perspective in which the work for the organization and realization of the 13<sup>th</sup> edition of the Italy-China Science, Technology and Innovation Week took place, a work that Fondazione Idis-Città della Scienza carried out in agreement with the Ministry of University and Research and in collaboration with

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<sup>2</sup> Pope Francis’ speech on the occasion of the international convention “Solidarity, Cooperation and Responsibility: the antidotes to fight injustices, inequalities and exclusions” organized by the Fondazione Centesimus Annus, October 21-22, 2021.

the National Research Council, starting from the priorities identified in the Action Plan for the strengthening of the China-Italy Global Strategic Partnership (2024-2027). This was a team effort that saw the universities, research centers and all those in the world of innovation who care about sustainability and responsibility at the forefront. In this context, Fondazione Idis-Città della Scienza joined the team effort with actions taken were perfectly in line with its statutory principles, particularly with the promotion and dissemination of scientific, technological, humanistic and artistic culture, and with the view to contribute to the development of a knowledge-based society in a truly democratic direction where the benefits that the growth of knowledge in the various fields can offer possibly will spread to all social actors, from institutions to associations, companies and individual citizens.

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# **OPENINGS**

## **Institutional Speeches**



## THE VALUE OF SCIENCE AND TECHNOLOGY IN ADDRESSING THE GREAT CHALLENGES OF OUR TIME

*Riccardo Villari*

President of Fondazione Idis-Città della Scienza

It is a great honor to host the opening ceremony of the 13<sup>th</sup> Italy-China Science, Technology, and Innovation Week at Città della Scienza.

This event brings us together with esteemed representatives from both nations to celebrate Italy-China cooperation and reaffirm the Global Strategic Partnership. We mark the 20<sup>th</sup> anniversary of the enduring friendship between our two countries. This edition also commemorates the 700<sup>th</sup> anniversary of the passing of Marco Polo, the Venetian traveler who played a pivotal role in forging connections between Italy and China.

The presence at the opening ceremony of Minister of University and Research of the Italian Republic, Anna Maria Bernini, and Minister of Science and Technology of the People's Republic of China, Yin Hejun, underscores the strong collaboration that has supported the Italy-China Week for the past 15 years. Their participation reaffirms a shared commitment to advancing scientific research and innovation, strengthening the bond between institutions, and fostering new opportunities for cooperation.

We inaugurate this edition's themes with the valuable contributions of two distinguished keynote speakers, Professor Cui Peng of the Chinese Academy of Sciences and Professor Oliviero Diliberto, Dean of the Faculty of Law at Sapienza University of Rome, whose reflections offer valuable insights into the broader context of Italy-China cooperation.

Italy and China, with their rich cultural, scientific, and technological heritage, continue to explore new opportunities for collaboration in strategic sectors. Special attention is dedicated to various fields of innovation with the common objective of promoting sustainability in all its dimensions: environmental, social, and economic. Both nations recognize the urgency of addressing global challenges that require coordinated responses beyond national borders.

The defining milestone in bilateral relations was the establishment of diplomatic ties in 1970. Later followed the signing of the Global Strategic Partnership in 2004. Throughout this time, high-level exchanges have deepened mutual trust and expanded strategic cooperation, strengthening exchange and improving mutual understanding. In July 2024 – on the occasion of the 20<sup>th</sup> anniversary of the “*Partenariato Strategico. Globale*” - the two countries reaffirmed the enduring commitment through the signing of the “2024-

*2027 Action Plan*”, which serves as the current framework in guiding structured scientific and technological collaboration. In line with this renewed agreement, extensive joint efforts have been made to curate the thematic agenda of this edition, ensuring the sessions reflect the evolving priorities and shared ambitions.

These sessions focus on key areas such as:

- The conservation of artistic and cultural heritage emerges as a strategic field where digital technologies and scientific innovation are increasingly employed to protect and enhance both tangible and intangible heritage.
- Food production and processing systems represent a key area of integration of science, advanced technologies, and traditional knowledge to develop sustainable, resilient, and competitive agri-food chains to address global food security challenges.
- Climate change and biodiversity are addressed through the development of international scientific strategies aimed at mitigating environmental impacts and preserving vital ecosystems, global observation networks, and innovative solutions.
- Disaster risk reduction highlights the importance of interdisciplinary research and international collaboration in strengthening the resilience of territories vulnerable to natural hazards.
- Advanced manufacturing explores the transformative potential of robotics, artificial intelligence, and automation, which reshape human–machine interactions and redefines the landscape of industrial innovation.
- Coasts, seas, and oceans are examined through the lens of sustainable monitoring management and responsible conservation of marine and coastal ecosystems increasingly affected by anthropogenic pressures.
- Polar sciences focus on research conducted in the Arctic, Antarctic and Third Pole regions to understand the planet’s climate systems and reinforce international scientific cooperation for environmental challenges of the future.

Once again, the Italy-China Science, Technology, and Innovation Week at Città della Scienza has been held in person at this venue, in the Città della Scienza. A special focus has been given to the 700<sup>th</sup> anniversary of Marco Polo’s death, with a dedicated collaboration involving Ca’ Foscari University of Venice and its Rector, Professor Tiziana Lippiello. This historic anniversary serves as a guiding light for the future, paving the way for new achievements, deeper collaboration, and the advancement of shared knowledge.

This event serves as a vital platform for international collaboration, facilitating the signings of agreements that enhance bilateral partnerships. Cornerstones of this initiative is the *Sino-Italian Exchange Event*, launched in Naples in 2007 by Città della Scienza and the Campania Region. In cooperation with the Beijing Association for Science and Technology (BAST) and the Municipality of Beijing, the event has developed a new format: a national platform aims to foster scientific and technological exchange, business-research

partnerships, and mutual investment opportunities between the two countries, the *China-Italy Innovation Forum*. The merge of these two initiatives has successfully been shaped into what is now the *Italy-China Science, Technology, and Innovation Week*. Its outcome is reflected not only in the numbers – over 10,000 experts engaged and approximately 150 cooperation agreements signed over the past fifteen years – but also in the fostering of meaningful exchange of ideas, the development of scientific cooperations, and the creation of new business opportunities. Over the past 15 years, this bridge between Naples and Beijing has been crossed in turn, strengthening a path of ongoing dialogue and deepening mutual understanding. Each edition has provided a space for meaningful exchanges, with One-to-One meetings fostering new prospects for cooperation. This year, approximately 150 Italian and Chinese experts from academic, business, and institutional sectors are participating, further reinforcing the commitment to shared progress.

Città della Scienza continues its work with the professionalism and expertise that define its approach, leveraging its extensive network of partnerships and following the path outlined by the Ministry of University and Research of the Italian Republic, and with the same collaborative spirit that has shaped the evolution of the Italy-China Science, Technology, and Innovation Week. Città della Scienza continues to play a central role in coordinating and promoting this initiative. Its efforts are supported by a dedicated office working synergistically with other units of the Foundation, the Knowledge Dissemination Area, which has effectively worked with the whole staff of the Foundation to host such an important event in Città della Scienza. Città della Scienza showcases its support in the Italy-China relations to ensure continuity and further growth.



## STRENGTHENING ITALY-CHINA INNOVATION COOPERATION FOR A SHARED TECHNOLOGICAL FUTURE

*Zhang Yulei*

Deputy Director of the Beijing Municipal Science and Technology Commission

The Silk Road has long served as a bridge between Italy and China, fostering centuries of cultural and scientific exchanges. This year holds special significance as we commemorate the 700<sup>th</sup> anniversary of Marco Polo's passing and celebrate the 20<sup>th</sup> anniversary of the Italy-China Comprehensive Strategic Partnership. Recent visits by President Mattarella and Prime Minister Meloni to China, along with their extensive discussions with President Xi Jinping, have further strengthened the foundation for deeper collaboration. Notably, President Xi highlighted the importance of the Italy-China Innovation Cooperation Week in his remarks, reaffirming the commitment to expanding scientific and technological partnerships.

Beijing stands as a global center for education, research, and innovation. The city is home to over 90 universities, more than 1,000 research institutes, 77 national key laboratories, and 835 academicians from the Chinese Academy of Sciences and the Chinese Academy of Engineering – accounting for half of China's top scientific minds. With research and development expenditures consistently exceeding 6% of GDP, Beijing is at the forefront of global scientific advancement. This year, the Clarivate Analytics ranking identified 433 highly cited scientists in Beijing, placing it first among global cities. Additionally, Beijing ranks third worldwide in the 2024 International Science and Technology Innovation Center Index by Springer Nature and remains among the top clusters in the World Intellectual Property Organization's Global Innovation Ranking.

To transform research strengths into industrial advantages and foster new productivity, Beijing has prioritized the commercialization of scientific achievements. The city has established two trillion yuan (approximately \$138 billion) industrial clusters in next-generation information technology and scientific services, along with eight billion-dollar clusters in sectors such as biotechnology, integrated circuits, and quantum computing. Leading technology firms such as ByteDance, Xiaomi, JD.com, and Baidu originated in Zhongguancun and have expanded globally since then. Every day, an average of 337 new technology companies are established in Beijing, and the city now hosts 114 unicorn companies, second only to Silicon Valley and New York.

As a globally connected innovation hub, Beijing actively supports foreign research institutions through specialized policies and initiatives. The city is home to nearly 500

incubators, accelerators, and university technology parks, along with 1,800 venture capital and private equity firms, ensuring a dynamic ecosystem that fosters technological progress.

Reflecting on the journey of the Italy-China Innovation Cooperation Week, Beijing has actively participated in the event since 2011, and this marks the tenth edition in which the city has played a key role. Through this platform, significant milestones have been achieved, including the establishment of the China-Italy Advanced Manufacturing Joint Laboratory and the Sino-Italian Design Innovation Hub. Today, further collaborations will be formalized with the signing of five new cooperation agreements between Beijing's research institutions and Italian partners.

Particularly noteworthy is the focus on ocean and polar sciences, where numerous research teams are advancing collaborative projects. As both nations face critical environmental challenges, deeper scientific partnerships in these fields will play a crucial role in shaping a sustainable future.

Looking ahead, the 2025 edition of the Italy-China Innovation Cooperation Week is hosted in Beijing, alongside the Zhongguancun Forum Annual Conference (April 2024). I extend a heartfelt invitation to Italian scientists, entrepreneurs, and innovators to join us in Beijing for the 14<sup>th</sup> Italy-China Innovation Cooperation Week to share research achievements and strengthen long-term innovation partnerships.

Through our collective efforts, we can harness the power of science and technology to address global challenges and build a brighter future for all.

## THE CAMPANIA REGION FOR THE COOPERATION ITALY-CHINA

*Valeria Fascione*

Regional Minister for Research, Innovation and Startups of Campania Region

I am pleased to open the XIII Edition of the Italy-China Week on Science, Technology, and Innovation. On behalf of the President of the Campania Region, Vincenzo De Luca, I would like to express my sincere gratitude and welcome to Naples the Chinese Minister of Science and Technology, Yin Hejun, and the Ministry of University and Research of Italian Republic, Anna Maria Bernini.

I also want to express my deep appreciation for the collaboration with China, which we have been fostering for many years. It is an honour for us to be part of such an important event, bringing together universities, research centres, innovative businesses, and institutions from both of our countries.

On a personal note, I have had the privilege of overseeing the Sino-Italian Exchange Event (SIEE) as Regional Councillor for many years, a program of cooperation between the Campania Region and the Municipality of Beijing. This event, organized by Città della Scienza, has been running for 15 years and, since 2012, has been held alongside the Italy-China Week. Over the years, the SIEE has become a crucial international platform for networking, emphasizing the strategic pillars of our local system: human capital, research, and the entrepreneurial world.

A heartfelt thank you goes to the coordinators of today's initiative, Riccardo Villari, President of Città della Scienza, and Zhang Yulei, Vice Director of the Scientific and Technological Commission of Beijing, as well as to the teams behind the realization of this thirteenth edition, and to the CNR for their invaluable contribution.

I am confident that today will be another successful occasion, with collaboration agreements being signed, one-to-one meetings fostering new academic, scientific, and industrial partnerships, and thematic forums aligned with the Action Plan to strengthen the Global Strategic Partnership between China and Italy for the period 2024-2027.

The Campania research and innovation ecosystem, represented by a distinguished delegation today, is characterized by a wealth of expertise, products, and services of excellence. The areas discussed in the working sessions are of high potential, as they are key points of our smart specialization strategy, where innovation can be leveraged to modernize production systems and address the challenges of the digital and green transitions.

The first thematic forum, focusing on the Preservation of Artistic and Cultural Heritage, addresses an area where our two countries have a long-standing history of

collaboration. Italy and China hold the highest number of UNESCO recognitions, and Campania contributes with 10 UNESCO sites, 7 of which are tangible, including the archaeological site of Pompei, and 3 are intangible, such as the Mediterranean diet. Our collaboration extends beyond organizing joint exhibitions to more innovative fields, as seen in the partnership between Campania and Sichuan in the exchange of methodologies and expertise related to earthquake risk mitigation and the preservation and restoration of cultural heritage damaged by seismic events. This partnership culminated in the 2021 Campania-Sichuan Forum.

The second thematic focus is the Food Production and Processing Systems, in which our region stands out with the National AGRITECH Center for developing new agricultural technologies, led by the University of Federico II. Additionally, Farming Future, the National Agricultural Technology Transfer Hub supported by CDP Venture Capital, was recently launched with the mission of transforming innovations developed by Italian scientists into frontier products for global markets. I also want to highlight the remarkable work of the Zooprohylactic Institute of the Mezzogiorno, which conducts surveillance, control, and scientific research from a One Health perspective.

Regarding Climate Change and Biodiversity and Disaster Risk Reduction, Campania hosts Return (Multi-risk Science for Resilient Communities Under a Changing Climate), a partnership that aims to strengthen research on environmental, natural, and anthropic risks at the national level and promote participation in key European and global value chains. Furthermore, the Euro-Mediterranean Center on Climate Change in Caserta conducts research on climate change and the evaluation of local impacts.

Advanced Manufacturing is a key sector in which we have invested heavily in Campania, with the presence of national and international organizations such as the European Digital Innovation Hub, the National Digital Innovation Hubs, and the MedITech Competence Center. I would like to mention the China-Italy Laboratory on Advanced Manufacturing, a collaboration platform between the innovation ecosystems of China and Italy in the field of advanced manufacturing. The project is now in its fifth edition, with academic partners including the University of Bergamo, the University of Naples Federico II, and Tsinghua University.

In conclusion, the themes addressed in this thirteenth edition reflect areas where we can and want to foster collaboration, particularly with China.

As Campania Region, we firmly believe in strategies focused on international openness and the development of new collaborations, keeping in mind the urgency and necessity of uniting resources and expertise for a better future.

## NAPLES, BIG CITIES AND CURRENT CHALLENGES

*Gaetano Manfredi*

Mayor of Naples

Authorities, Ministers, welcome to Naples. A warm greeting to the Minister of the People's Republic of China, Yin Hejun, and an affectionate welcome to Anna Maria Bernini, an esteemed guest in our city.

The Italian-Chinese Week represents a fundamental event in the scientific and diplomatic relations between our two countries and finds a natural home in Naples. The relations between our city and China, seen not only as a great nation but also as a great civilization, have deep roots in a long history. The Collegio dei Cinesi, founded in Naples in 1732, was the first place in Italy where the Chinese language and culture were taught. Today, that college has become L'Orientale University. This data demonstrates how strong and solid the cultural bond between our city and the Chinese people has always been: a relationship built on great friendship and intense exchange. For this reason, as mayor of Naples, I would like to express my deep gratitude to the entire Chinese delegation, and in particular to the Minister Yin Hejun, for his presence in our city.

Today we are facing crucial challenges, well-illustrated by the themes at the center of the scientific exchanges of the thirteenth edition of the Italy-China Week of Science, Technology and Innovation. Challenges that find their natural place in cities, particularly in large metropolitan areas, where they can be addressed and overcome. We live in increasingly complex systems, both socially and environmentally. Growing urbanization demands the use of research and technological innovation as essential tools to provide concrete solutions to the need of citizens.

Naples, with the largest historic center in Europe protected by UNESCO, is called to combine the conservation and enhancement of its cultural heritage with the active and sustainable use of these spaces, within a densely populated and vibrant city. This is a significant challenge, and only through the intelligent use of technology will we be able to achieve sustainable conservation and valorization of our extraordinary heritage.

Another central theme is the environmental transition. Climate change confronts us with increasingly complex challenges, such as the rise in extreme events with particularly significant impacts in highly urbanized areas. Cities must therefore develop new risk management and mitigation strategies, which have never before been addressed with this level of complexity. It is essential to adopt a multi-risk approach and utilize advanced technologies for prevention, forecasting, management and warning, in order to ensure safety and promote sustainable development.

These are crucial challenges for our researchers, for our technologists, for public administrations that must be able to integrate innovation into their public government policies, but also for citizens, who must embrace technological transformation as a great opportunity to improve living conditions.

I would like to conclude with a heartfelt thanks for choosing Naples as the venue for this meeting and with the hope that the Italian-Chinese Week will continue to be a fundamental point of reference for friendship, cooperation and shared growth between our two extraordinary countries.

## ADDRESS AT THE OPENING CEREMONY OF THE 13<sup>TH</sup> ITALY-CHINA SCIENCE, TECHNOLOGY AND INNOVATION WEEK

*Tiziana Lippiello*

Rector of Ca' Foscari University of Venice

Distinguished Authorities, dear Colleagues and Students,

I am very delighted to welcome you to this edition of Città della Scienza 2024, and in particular to Ca' Foscari University of Venice, here at our Scientific Campus, which hosts the Department of Molecular Sciences and Nanosystems and the Department of Environmental Sciences, Computer Science and Statistics.

A warm welcome to President Zhang Zongyi 張宗益 of Xiamen University 廈門大學, to Deputy Head of Mission Minister of the Italian Embassy in Beijing Cristina Parenza, and to Professor Alessandra Guidi, Scientific Attaché at the same embassy – thank you for joining us today.

One of the principal cities Marco Polo visited during his journey to China was the ancient port of Zaiton, known today as Quanzhou 泉州, near Xiamen in the Fujian province. At the time, it was one of the world's largest and most important ports, a strategic hub for maritime routes and global trade. The presence of President Zhang Zongyi of Xiamen University here today is therefore deeply symbolic, especially as 2024 marks the year of the Marco Polo commemorations.

For Venice, Marco Polo's journey was not only the story of a remarkable individual, but it also became part of the city's living identity. Venice has always been a place where worlds meet, where knowledge and ideas travel alongside goods and people. This legacy continues today in the mission of Ca' Foscari: to foster intercultural dialogue, openness, and cooperation, not as a memory of the past, but as a responsibility for the present and the future. In this sense, our collaboration with Xiamen University exemplifies how the spirit of Marco Polo can be renewed in contemporary academia and research.

Equally emblematic is the role of Naples and Venice as cultural bridges along the ancient and modern Silk Roads. Naples, with the Orientale University – one of Europe's oldest institutions dedicated to Asian languages and cultures – and the historic Collegio dei Cinesi, and Venice, with Ca' Foscari University, embody a natural and historical gateway to China, enriched today by its expertise in sinology, economics, cultural heritage, and scientific research. Together, Naples and Venice stand as twin pillars of Italy's engagement with China, linking history to the future through education, culture, and innovation.

Marco Polo's accounts opened a gateway of mutual understanding between East and West. In this same spirit, the participation of Xiamen University – a leading institution recognized under China's national Project 211 and Project 985, and now a key member of the Double First-Class Initiative – symbolizes the enduring academic and cultural connections between Italy and China. Xiamen University excels in several disciplines of global relevance, including economics, oceanography, and chemistry, making today's event even more meaningful.

I am also pleased to welcome Director Liu Aizhong 刘爱忠 of the Wenzhou Institute of the University of the Chinese Academy of Sciences (CAS). Today, a Memorandum of Understanding will be signed between the Wenzhou Institute and the Department of Molecular Sciences and Nanosystems of Ca' Foscari University, marking a significant step forward in our collaborative research efforts.

This Venetian gathering is dedicated to themes of coasts, seas, and oceans—seeking scientific solutions for the protection and sustainable management of coastal and marine ecosystems. It also encompasses the polar sciences, focusing on the study of polar regions and their environmental dynamics, which are of growing global concern.

Allow me to conclude with the words exchanged by President Xi Jinping and President Sergio Mattarella during the Italian Head of State's official visit to Beijing just three weeks ago:

“The long-standing history of exchanges and friendship between our two countries has enriched and deepened our mutual ties. Marco Polo opened a window for mutual understanding, creating a shared history that serves as a model of dialogue and reciprocal development between Italy and China”.

In this spirit, through an open and inclusive approach to science and culture, we can overcome divisions and conflicts, promote unity and peaceful coexistence, and together build pathways towards sustainable development.

This is why today's event, as well as the sessions in Naples, carries such profound importance. Italy and China share a millennia-long tradition of culture, civilization, and friendship. Equally vital is the advancement of scientific collaboration, carried out in the name of mutual respect and reciprocity.

Thank you all for being here, and I wish you a productive and inspiring day of work.

## ADDRESS AT THE OPENING CEREMONY OF THE 13<sup>TH</sup> ITALY-CHINA SCIENCE, TECHNOLOGY AND INNOVATION WEEK

*Zhang Zongyi*

President of Xiamen University

On the occasion of the 20<sup>th</sup> anniversary of the establishment of the China-Italy Comprehensive Strategic Partnership, it is a great honor to be invited to participate in the 13<sup>th</sup> China-Italy Science, Technology and Innovation Week. Here, on behalf of Xiamen University, I would like to express our sincere gratitude to the organizing committee and highest respect to all distinguished guests present.

Key to human survival, connectivity and development, the future of the ocean is intertwined with the future of humanity. Xiamen University was born because of the ocean, built facing the ocean, and nurtured by the ocean, forming a unique marine culture.

As early as 1923, American professor S.F. Light of Xiamen University discovered the Amphioxus (lancelet – a “living fossil” crucial to understanding chordate evolutionary development – in Xiamen’s waters. His groundbreaking research was published in the prestigious journal *Science*, marking the beginning of Xiamen University’s renowned legacy in marine research, which gained global academic recognition alongside the Xiamen Amphioxus.

In 1946, Xiamen University established China’s first Department of Oceanography and the first Marine Research Institute and is thus acclaimed as the “blue cradle” of China’s modern marine disciplines. Through generations of dedication, Xiamen University’s marine disciplines have now become a leading hub for marine scientific research and talent cultivation in China. Currently, Xiamen University stands as the only university globally with an independent comprehensive “sea-land-space” observation system, which includes: the 3,000-ton “Tan Kah Kee” comprehensive marine research vessel; the “HISEA” satellites, and the National Observation and Research Station. This system provides robust support for ocean observation and scientific expeditions.

Xiamen University proposed early on that “the ocean is a vast application field” and advocated for “all disciplines to engage with the ocean”, clearly positioning itself in the marine domain. We are committed to advancing the construction of a marine discipline cluster through an interdisciplinary approach, integrating strengths in marine science, environmental science, economics, information technology, chemistry, and biology. This has led to the active development of an “Ocean+” applied discipline cluster, significantly driving the formation of internationally competitive industrial clusters in areas such as

ocean carbon sequestration, marine digital twinning, marine renewable energy, and marine biomedicine.

Here are some examples. Our mangrove ecological restoration project has pioneered a new model of “ecology + economy” synergistic development. The experimental mangrove forest at Xiamen’s Xiatanwei Park has become an international benchmark for coastal ecological disaster mitigation and synergistic benefits. We established China’s most comprehensive live germplasm resource bank for abalone, breeding and widely promoting a series of new aquaculture varieties. Over the past five years, these efforts have generated CNY 54.1 billion in cumulative output value. We have also produced original, internationally advanced achievements including: antimicrobial peptide products; breeding chips for large yellow croaker; environmentally friendly marine antifouling coatings, etc.

To harness the immense potential of ocean carbon sequestration in achieving carbon neutrality goals, Xiamen University spearheaded the Global Ocean Negative Emissions (ONCE) Initiative in 2022. To date, it has engaged 33 countries, 79 research institutions, and over 1,500 leading scientists worldwide. This “Mega Science” project has been incorporated into the UN Decade of Ocean Science for Sustainable Development. We hope to work with global universities and research institutions to advance high-level, multi-channel international scientific cooperation, facilitate the global flow and efficient allocation of innovative resources, and contribute more technological solutions to enhancing ocean well-being and building a community with a shared future for the ocean.

As a Chinese saying goes, “No mountain or ocean can distance people with shared aspirations”. Similarly, an Italian proverb reminds us, “Friendships are not chosen by chance, but according to the passions that dominate us”. Currently, Xiamen University has been engaged in substantive collaborations with institutions such as Ca’ Foscari University of Venice and Sapienza University of Rome, with the cooperation between our marine science discipline and Institutes of Marine Research, CNR entering a new phase. Looking forward, we earnestly hope for closer ties in higher education between our two nations that helps extent the breadth and depth of our cultural, technological, and academic exchanges. Let us actively contribute to the China-Italy friendly cooperation, the mutual learning among civilizations, and the community with a shared future for mankind, thereby injecting new and powerful momentum into the sustained deepening of China-Italy relations.

Finally, I wish this event a resounding success!

Thank you!

# COASTS, SEAS, OCEAN AND POLAR SCIENCES: ITALIAN MINISTRY OF UNIVERSITY AND RESEARCH'S INITIATIVES AND ACTIONS HIGHLIGHTED DURING THE ITALY-CHINA SCIENCE, TECHNOLOGY AND INNOVATION WEEK

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## Summary

Last November, the 13<sup>th</sup> edition of the China-Italy Science, Technology and Innovation Week involved two thematic Sessions focused on two essential topics for the Italian scientific community: “*coasts, seas and ocean*” and “*polar sciences*”. The thematic sessions were held in Venice, at Ca’ Foscari University, both to celebrate the seven-hundredth anniversary of Marco Polo’s death and to underline the historical role of Venice in research and exploration of the seas.

These sessions underlined the commitment of the Ministry of University and Research of the Italian Republic (MUR) to promoting research and innovation in the essential scientific areas mentioned above. This article intends to show MUR’s commitment by highlighting the documents on which MUR’s actions are based and showcasing the initiatives undertaken.

As far as research in the field of coasts, seas, and ocean, Italy coordinates, along with Norway, the *Sustainable Blue Economy Partnership (SBEP)*; supports the objectives of the Mission “*Restore our Ocean and Waters by 2030*” promoted by the European Union; and participates in the implementation of different multilateral initiatives at the G7, G20 and United Nations levels.

When it comes to polar research, following the 2018 Budget Law (Law No. 205 of December 27, 2017, points 1170 to 1177), Italy has established the *Arctic Research Program (PRA)* and the *Scientific Committee for the Arctic (CSA)*; in 2023, Italy participated in the *One Planet-Polar Summit*, held in Paris, and approved the *Ambition on Melting Ice (AMI), On Sea-level Rise and Mountain Water Resources Declaration*; between 2025 and 2026, Italy will host the *Arctic Circle Rome Forum*, together with a meeting of the *Polar Dialogue*, which will follow the *2025 Antarctic Treaty Consultative meeting* in Milan.

Although marked by distinct moments, this continuous process is characterized by different ongoing interactions and synergies, where the cooperation between Italy and

partner countries, such as China, plays a remarkable role.

During the opening ceremony of the above-mentioned thematic sessions, held in Venice at the Science Campus of Ca Foscari University on November 28, 2024, Dr. Michele Mazzola expounded the relevant initiatives reported below in this article.

### **Introduction: a relevant opportunity to foster dialogue on Coasts, Seas, Ocean, and Polar Sciences**

Over the last few years, the China-Italy Science, Technology and Innovation Week has become a remarkable event for the relations between Italy and China. Specifically, as the Ministry of University and Research of the Italian Republic, Senator Professor Anna Maria Bernini, said during the Innovation Week's opening speech, given in Naples last November, "The Innovation Week represents an important occasion to foster dialogue, share ideas, define new joint projects and, in general, strengthen the already strong scientific relations between the two countries".

### **Coasts, Seas and Ocean: SBEP and EU Mission. Italy's continuous and growing commitment**

MUR is engaged in advancing scientific research in the fields of seas and ocean and believes in the importance of promoting international collaboration with a particular focus on the Mediterranean Sea and Atlantic Ocean.

As Minister Bernini has highlighted on different occasions, protecting, conserving, and restoring seas, ocean, and their biodiversity are some of the significant challenges of this century. Seas and ocean are arguably the largest living space on the planet. They remain largely unexplored and represent essential resources for sustaining life on Earth. The loss of biodiversity and global warming are damaging the integrity and functioning of ecosystems while threatening the populations which heavily depend on them.

MUR is committed to developing strategies for the regeneration of marine biodiversity and ecosystems, improving climate mitigation and adaptation to the climate-ocean nexus, and strengthening the resilience of coastal communities. Advancing research in these areas enables progress in combating the increasingly threatening effects of severe weather events, storms, hurricanes, ice melt, and sea level rise.

Italy's active participation in international initiatives to achieve these goals is evident. Last July, MUR and the European Commission organized the "EU High-Level Conference on Mediterranean and Atlantic Ocean Health and Coastal Resilience" in the context of the Italian G7 Science and Technology Presidency. The event formalized the official endorsement of the *EU's Restore our Ocean and Waters Mission*, which intends to protect and restore the

health of ocean and waters through research and innovation, citizen engagement and blue investments by 2030.

Moreover, Italy supports the implementation of the *United Nations Decade of Ocean Science for Sustainable Development (2021-2030) and its Ocean Decade Vision 2030*, welcomes the related *Barcelona Statement*, the outcome of the *2024 Ocean Decade Conference*, and looks forward to the *2025 United Nations Ocean Conference in Nice* (which will be organized by the Governments of France and Costa Rica). In addition, Italy supports the further development of concrete G7 strategies based on policy papers such as the “*G7 Ocean Decade Navigation Plan*” and the “*G7 Ocean Deal*” to connect science to policy, translate knowledge into action, and ensure a sustainable, resilient, and productive blue economy.

During the last *G7 Science and Technology Ministerial Meeting*, held in Bologna last July, and the *G20 Research and Innovation Ministerial Meeting*, held in Manaus last September, it was highlighted that over the last few years, the concept of the blue economy had become a strategic priority for the Italian government.

Italy is firmly committed to turning its economy into a driver of sustainability and coordinates the *Sustainable Blue Economy Partnership (SBEP)*, under Horizon Europe (the European Union’s key funding programme for research and innovation for the years 2021-2027), which will enable an inclusive transition toward a climate-neutral, sustainable and productive blue economy by contributing to the global Earth observation system. The partnership is a real gateway to the future for forward-thinking Italian and European research, also at the global level.

The importance of international cooperation with partner countries in achieving these objectives is paramount. As Minister Bernini has repeatedly pointed out, to protect, conserve and restore our seas and ocean and their biodiversity, it is necessary to develop a continuous international cooperation approach with partner countries in all key sectors, avoiding those short-term interventions that could have negative environmental and socioeconomic impacts.

### **Polar science: a path to strengthen international cooperation in the fields of research and innovation for protecting the cryosphere.**

The *Paris Call for Glaciers and Poles Declaration*, launched on November 10, 2023, within the context of the *One Planet – Polar Summit*, reported that Polar regions are among the most vulnerable areas on our planet. They are undergoing rapid and severe changes, including ice melting and permafrost thawing. These transformations have devastating effects on biodiversity, local infrastructure, and the way of life for native peoples, with repercussions felt worldwide. Advancing research in these regions is crucial to studying the intensifying

impacts of climate change, preserving our planet, and making significant strides toward a sustainable future.

This is indeed a critical decade for people and the planet. Extreme weather, rising temperatures and sea levels, devastating events such as droughts, floods, wildfires, marine warming, ocean acidification, and record lows in sea ice extent are becoming increasingly prevalent, affecting ecosystems, economies, and human well-being worldwide. To effectively address these challenges and ensure a sustainable future for the next generations, MUR considers it crucial to invest in research and enhance both scientific and public awareness regarding the essential role that polar regions play in achieving our collective goals.

Over the past 40 years, Italy has strengthened its long-term observational activities in both the Arctic and Antarctic. In Antarctica, the Italian National Research Council (CNR) participates in the *National Program for Research in Antarctica (PNRA)*, financed by the Italian Ministry of Universities and Research. PNRA involves several national research facilities, such as the “*Mario Zucchelli*” *Research Station*, located in Terra Nova Bay on the Ross Sea, and the *Concordia Research Station*, established in the Antarctic Plateau, which is a remarkable example of logistic and scientific international cooperation.

Likewise, concerning the Arctic, MUR finances the Italian *National Arctic Research Program (PRA)* with more than 1 million euros per year. CNR has run the “*Dirigibile Italia*” *Research Station* since 1997. This laboratory hosts researchers engaged in studies ranging from atmospheric chemistry/physics to marine biology, oceanography, environmental studies, biology and medicine.

MUR conducts research activities in the Polar regions using a strongly multi-disciplinary, holistic and coordinated approach. That’s because the ecosystems of this planet are deeply interconnected. What happens in a specific area of the World has evident effects globally. This is especially true in the Polar regions. The *13<sup>th</sup> edition of the China-Italy Science, Technology and Innovation Week* has shown that Italy and China are ready to do their part in promoting scientific research to study and protect these remote areas. In Antarctica, on the Ross Sea (the largest marine protected area in the World), the *Italian “Mario Zucchelli” Research Station* and the *new important Chinese polar research station* are only a few miles away. Right there, at the edges of the Planet, Italy and China have a great opportunity to demonstrate how dialogue, collaboration, and the sharing of data and research can promote collective progress, with benefits for all.

## **Conclusion**

The great challenges of these times are giving us, albeit at a high price, a valuable lesson: there is only one clear direction to successfully face them and give future generations a society which meets their expectations. Specifically, it is necessary to strongly support

scientific research and education, promote coherent scientific communication, improve science diplomacy and lead our efforts toward a new phase of international cooperation to protect, preserve and restore seas, ocean and polar regions and, therefore, the planet. The scientific cooperation between Italian and Chinese researchers plays a crucial role in this pathway.

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## **OPENINGS**

**Keynote Speeches**



**LAW AND THE FUTURE.  
SCIENCE, NEW TECHNOLOGIES, AND THE NEED FOR SHARED RULES**

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**Keywords:** twin transition, digital and ecological advancements, legal challenges, Chinese Civil Code, privacy, data protection, virtual network assets, image rights, intellectual property, contracts for technological services, framework of shared rules

I am deeply grateful to Minister Bernini and the Città della Scienza in Naples for granting me the honour of speaking at the opening of this Italy-China Week. This event coincides with two significant anniversaries: twenty years of economic partnership between Italy and China, and seven hundred years after Marco Polo's death.

I am not a scientist, nor do I work in advanced technologies. I am a jurist, but for the past twenty-five years, I had the privilege to collaborate with China in the field of law.

My remarks today will focus on the role legal science plays in Italian - Chinese cooperation and the importance of shared rules in addressing the topics of this Week.

The key themes of this meeting encompass the preservation and enhancement of artistic and cultural heritage; innovations in food production and processing systems; the impacts of climate change and strategies to reduce natural disaster risks; advanced manufacturing technologies with an emphasis on digitalization, automation, and innovative materials; coasts, seas, and oceans and, all in all, polar sciences.

These themes resonate with the words of our President of the Republic, Sergio Mattarella who, on the 11<sup>th</sup> April 2024, emphasized the interconnected issues of food security, health protection and poverty alleviation during his recent state visit to China. President Mattarella eloquently stated that all these topics converge on a singular, unifying theme: (the President's words) "cultural heritage, which is like humanity's repository of wisdom. [When the] cultural heritage prevails, humanity is guided toward paths of progress, well-being, serenity, and peace."

Similarly, President Xi Jinping introduced the lofty and ambitious concept of a "shared future of humanity" twelve years ago. In President Xi's vision, our planet should be understood as an inclusive "community" where barriers, walls, and prejudices are dismantled, and various cultures and civilizations cooperate on equal footing, countering selfish worldviews.

The pandemic taught us (or should have taught us) that there are decisive challenges for our planet that can only be overcome through the sharing of scientific research, information, materials, and resources. Viruses recognize no boundaries. The hole in the ozone layer recognizes no boundaries. Melting glaciers recognize no boundaries. Nuclear waste recognizes no boundaries. The challenges facing humanity demand collective action.

In this context, the idea of a “twin transition” integrating digital and ecological advancements has emerged. This dual challenge is both ambitious and captivating and the law serves as a powerful weapon in addressing it.

It is no coincidence that President Xi Jinping, on several occasions, has committed himself precisely to the establishment of a legal perspective in China’s development: China, moreover, in President Xi’s view, must strive to build a rule of law. Governing the country according to law (Rule of Law) has been the CCP’s “core strategy” since the 18<sup>th</sup> National Congress.

Law offers an extraordinary avenue for dialogue between the West and the East. Over the years, China and Italy promoted a productive exchange in this area, yielding significant outcomes in research, in training young talents and addressing the legal challenges posed by rapid scientific advancements.

For as long as the world has existed, in fact, scientific and technological discoveries have always preceded their legal regulation, which necessarily occurs because of those detections.

Today a radical qualitative change occurred, the advent of the Web (in its many forms) sharply forced jurists to a radical rethink of traditional legal categories. This is a revolution that deeply interrogates - and subverts - all our categories of thought, the fruit of millennia of human reasoning.

One instance for all. Considering the fundamental classification of things from the time of the Institutions of the Roman jurist Gaius in the 2<sup>nd</sup> century A.D.: corporeal and incorporeal. However, for two millennia, corporeal things (those that can be touched, as defined by Gaius himself) dominated legal frameworks, while incorporeal things (those that cannot be touched) were almost fictitious, residual. All law was based on materiality and corporeality. Today, the relationship between the two categories of things is radically reversed, with incorporeal assets holding immense economic value. Such a revolution, therefore, imposes on the contemporary jurist a courageous effort. This shift demands bold efforts from contemporary jurists to craft an entirely new system of legal and moral rules, rights, prohibitions and responsibilities, grounded completely and courageously in reimagined legal and philosophical categories. This is the challenge of the future.

The planet is becoming more complex every day and, at the same time, increasingly interconnected: new technologies have indeed reset to zero the categories of space and time that humanity developed for millennia. But to all this is added a new challenge. The right

of space, the moon and other celestial bodies. More unprecedented scenarios. Other legal categories to be reset or adapted.

In a word, all these extraordinary novelties demand, once again, overwhelmingly, law.

In this sense, the Chinese Civil Code, which came into force on the 1<sup>st</sup> of January 2021 (the most recent among contemporary codes), is, certainly, the most innovative. For this reason, we immediately translated it into Italian (the first complete translation in the world by Professor Huang Meiling, who is also present today), thanks to the collaboration, now of many years, between Sapienza University of Rome and Zhongnan University of Economics and Law in Wuhan.

It is the only civil code, in fact, that legally regulates digital revolution and ecological transition (the “twin transition” I mentioned earlier). It regulates privacy, data protection, virtual network assets (arts. 111, 127, 1034-1039, 1194-1197), image rights (arts. 1018-1031), intellectual property (arts. 123, 444, 600, 1185); it regulates transfer and consulting contracts for technological services (arts. 862-887); but, at the same time, it is pointedly attentive to environmental issues (arts. 1229-1235). Novelty of extraordinary interest.

It is the law of the future because it harmonizes China’s millennia-old culture, the Civil Law legal system and the radical scientific innovations of the new era. Tradition and innovation, then.

But law, in this continuously interconnected world, can no longer be confined to national sovereignty, it must evolve into a global framework of shared rules. Law as one of the conceivable manifestations of the “shared future of humanity”.

Law builds bridges between cultures, civilizations, religions, and ideologies.

It is certainly not a coincidence that the first Roman jurists - from that people, ancient Rome, who literally invented legal science as a specialized science, autonomous from all others - were called *pontifices*, pontiffs: builders of bridges, therefore, that is, able to unite the two banks of a river and thus allow women and men to meet each other.



## RESPONDING TO THE RISKS OF CLIMATE CHANGE AND LEADING GREEN AND SUSTAINABLE DEVELOPMENT

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The participation in the 13<sup>th</sup> China-Italy Innovation Cooperation Week provided a valuable opportunity to engage with institutional representatives, scientific and technological experts, and business leaders from both countries, with the shared objective of advancing innovation-driven development. The event serves as a high-level platform for fostering dialogue and promoting mutually beneficial cooperation in science and technology between China and Italy.

The friendship between China and Italy has deep historical roots. For over 2,400 years, the ancient Silk Road connecting Chang'an and Rome served as a vital bridge for economic, cultural, scientific, and technological exchange between East and West, contributing to the social and economic development of both nations and those along their path. The legacy of Marco Polo, a shared cultural and historical reference for more than 700 years, continues to symbolize the enduring ties between the two countries. In today's era – marked by globalization, the profound impacts of climate change, and innovation-driven development – China-Italy cooperation assumes renewed significance and purpose.

At present, global warming leads to enhanced disturbances in multi-scale climate systems, resulting in an increase in extreme weather events, frequent flooding and droughts, geological disasters, accelerated melting of ice and snow, rising sea levels, and damaged ecosystems, which have significant impacts on agricultural production and human health<sup>1</sup>. The increasing climate change has caused many natural disasters, including high temperatures, droughts, fires, typhoons, rainstorms, floods, landslides and debris flow, to have new features, which are manifested in the increase of disaster intensity. Frequency, duration, harm scope, interaction among different disaster species, and spatial coupling of multi-disaster species<sup>2</sup>. The temporal and spatial pattern of disasters has also changed significantly. Fire weather and rainstorms and floods in arid and semi-arid areas have become the “new normal”, with frequent overlapping, chain-like and compound disasters, and the

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<sup>1</sup> IPCC 2021, 7-8.

<sup>2</sup> IPCC 2022, 7-9.

cascading effects and systemic risks have increased significantly<sup>3</sup>. These new phenomena, new trends and new mechanisms are beyond people's existing understanding of disaster risks, as well as the coping ability of existing disaster risk reduction technologies and risk management systems, which pose new challenges for human beings to cope with natural disaster risks and ensure people's life safety and social and economic development.

For example, in the summer of 2023, Typhoon Doksuri penetrated deep into the inland of China, bringing heavy rainfall that triggered severe flooding, landslides, and mudslides, causing a systemic major flood disaster in the Haihe River Basin, which severely affected Beijing and Hebei Province<sup>4</sup>. In the summer of the same year, European countries such as Italy, Greece, and France experienced heatwaves, with abnormally high sea surface temperatures in the Mediterranean, forming Hurricane Daniel, which made landfall in Libya with a maximum daily rainfall of 414.1 mm, far exceeding the annual total rainfall. Daniel caused severe flooding in multiple countries, including Greece and Turkey, leading to dam breaches and more than 10,000 fatalities. Prior to this, in the summer of 2022, Pakistan experienced the severe flood disaster in history. More than one-third of the country was flooded for a long time, killing about 1,700 people and severely affecting 33 million people, which caused a heavy blow to the local society and economy<sup>5</sup>.

Natural disasters are a common challenge faced by human society and an important social governance issue in the era of globalization, which requires the cooperation of the international community and joint response. In order to alleviate the severe situation of disaster risk caused by climate warming, we need to reduce greenhouse gas emissions at the source, effectively promote the green development model, and further build a strong and resilient society, significantly reducing sensitivity to natural disasters. These efforts will support the construction of a green and sustainable human habitat, moving together towards a better future.

China and Italy, both located on the Eurasian continent located in the youngest mountain ranges. The Qinghai-Tibet Plateau, Himalayas and Alps are active in structure, rising sharply and steep in terrain, which are "sensitive areas" and "amplifiers" of global climate change<sup>6</sup>. In the context of climate warming, the melting of glaciers, the degradation of permafrost, and the extremization of precipitation have further exacerbated disaster risks in mountainous areas<sup>7</sup>, posing enormous threats to the socio-economic development and

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<sup>3</sup> PESCAROLI, ALEXANDER 2018, 2245-2257; ZSCHEISCHLER *et al.* 2020, 333-347.

<sup>4</sup> WU *et al.* 2025, 1003.

<sup>5</sup> EBI *et al.* 2021, 293-315.

<sup>6</sup> PEPIN *et al.* 2022.

<sup>7</sup> WANG *et al.* 2024.

safety of the two countries<sup>8</sup>. The shared responsibility and mission of disaster prevention, reduction, as well as the safety of people's livelihood has connected Chinese and Italian scientists together and carried out extensive and in-depth cooperation and exchanges on the formation laws of natural disasters, risk evolution, monitoring and early warning, emergency management, risk governance, and post-disaster reconstruction, learning from each other and tackling problems collaboratively<sup>9</sup>. A series of innovative achievements have been made in the fields of seismic disasters, geological disasters, hydrological disasters, marine disasters, and cryosphere disasters, strongly supporting the disaster prevention, reduction, and relief efforts of both countries and generating significant social and economic benefits. The scientists of China and Italy not only publish their papers in academic journals but also "write" their papers on the lands of both countries, solving practical problems and benefiting the people of both nations.

This publication presents recent collaborative research carried out by the Institute of Mountain Hazards and Environment of the Chinese Academy of Sciences and the Research Institute for Geo-Hydrological Protection of the Italian National Research Council. In response to the disaster risks posed by climate change in high mountain areas, the Sino-Italian Joint Laboratory on Geological and Hydrological Hazards founded in 2013. With the Qinghai-Tibet Plateau and the Alps as our research areas, we have systematically carried out research on the formation, evolution, and risk prevention and control of geological disasters. Over the past decade of scientific and technological cooperation, our colleagues at the China-Italy Joint Laboratory have climbed snow-capped mountains together, crossed rivers, left footprints in the Alps, and sweated on the Qinghai-Tibet Plateau. We have installed monitoring instruments in landslide gullies, tested samples in laboratories, analyzed data in offices, and exchanged findings at international academic conferences.

We jointly developed the world's first numerical simulation platform that can be used to analyze the formation-evolution-disaster process of mountain disasters under different scenarios, breaking through the technical challenges of predicting and simulating mountain disasters. Italian scientists introduced the world-leading landslide monitoring and early warning technology to China and established a community disaster risk management demonstration zone in Longxi River basin in Wenchuan earthquake-stricken area, achieving dynamic monitoring, rapid transmission of disaster information, and community early warning<sup>10</sup>. Professor Alessandro Pasuto (Research Institute for Geo-Hydrological Protection of the Italian National Research Council) was awarded the 2023 "Tianfu Friendship Award". At this stage, we are jointly working to apply the newly developed geological disaster

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<sup>8</sup> KNIGHT 2022.

<sup>9</sup> RENN 2008.

<sup>10</sup> INTRIERI *et al.* 2018, 2211-2225.

movement simulation and refined forecasting and early warning system in the northern mountainous areas of Italy, with the hope of achieving more precise risk monitoring and early warning and contributing to disaster risk reduction in Italy.

Facing the future, in order to scientifically address the common challenges brought by the new trends, mechanisms, and emerging risks of natural disasters caused by climate change that go beyond current cognitive boundaries, scientists from China and Italy will deeply focus on the Alpine and Himalayan regions, which are sensitive to climate change and have typical disaster effects, to study the impact of climate change on the interaction processes of the Earth's spheres and its disaster-causing mechanisms, extreme weather-driven catastrophe prediction and risk evolution, catastrophe impact mechanism and risk assessment on social and economic systems, and the theory of resilient social construction adapted to climate change, and to develop targeted scientific issues. Fully integrate the wisdom of eastern and western cultures, build the concept, mechanism and model of disaster prevention and mitigation suitable for eastern and western countries, shape the cooperation paradigm of China and Italy to deal with the disaster risk of climate change, set a model of cooperative research and collaborative disaster reduction for the global disaster prevention and mitigation cause, and contribute unique solutions to the global climate change risk response.

Ladies and gentlemen, we are in an era full of challenges but also faced with unprecedented opportunities. As emphasized by President Xi Jinping during his joint meeting with Italian President Mattarella in Beijing on November 8<sup>th</sup>, with the representatives of the China-Italy Cultural Cooperation Mechanism Conference and the China-Italy University Presidents' Dialogue, "We should gather the forces of development with the vision of harmonious coexistence." I believe that through close cooperation between China and Italy, we can make greater progress in addressing climate change risks and contribute our wisdom and strength to the construction of a community with a shared future for mankind and to global sustainable development.

Looking back, China-Italy cooperation has a profound foundation and has benefited the people's livelihood of both countries.

Looking forward to the future, collaborative innovation will continue to write a brilliant chapter, leading the way in green development.

In closing, I extend my best wishes for the success of the 13th China-Italy Innovation Cooperation Week, and for the opening of a new chapter in innovation and cooperation between China and Italy.

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## **OPENINGS**

### **Ministers' Speeches**



## MINISTER ANNA MARIA BERNINI'S SPEECH

*Anna Maria Bernini*

Minister of University and Research of the Italian Republic

Minister Yin, Distinguished authorities, Esteemed representatives of the academic, business, and research communities, it is a true honour to be here today at the opening ceremony of the 13<sup>th</sup> Italy-China Science, Technology and Innovation Week, which over the years has come to represent a cornerstone in the relations between our two nations.

I would like to express my sincere appreciation to the President of the Foundation IDIS-Città della Scienza Riccardo Villari, for the warm hospitality and the flawless organisation of this event. My sincere gratitude also goes to our hosts – the Mayor of Naples, Professor Gaetano Manfredi, and Councillor Valeria Fascione.

I am equally grateful to all the University Rectors in attendance, and to our keynote speakers, Professor Oliviero Diliberto and Professor Cui Peng, whose presence reflects the deep interconnection and mutual enrichment between technology and the humanities.

The Italy-China Science, Technology and Innovation Week serves as a vital platform for our scientific communities to engage in dialogue, exchange ideas and projects, and continue to strengthen the strong and well-established scientific bonds that unite us. The collaboration agreements between our universities and our research institutions, which have long connected our two countries, have been rightly mentioned. We believe that these agreements are, without doubt, a vital basis for enhancing the depth and meaning of our cooperation.

Year after year, the Italy-China Week fosters the launch of meaningful initiatives and, most importantly, promotes contacts and mobility between Italian and Chinese researchers. For this reason, Italy has full confidence in this platform as a primary instrument for technological and scientific cooperation with China.

As President Villari recalled, since 2013 this initiative has brought together over 10,000 professionals – including researchers, academics, and entrepreneurs – and has facilitated more than 5,000 high-value matchmaking activities among research centres, universities, and businesses, leading to the signing of numerous agreements and partnerships.

Beyond its quantifiable scientific achievements in the short term, this exchange platform also aims to accomplish broader and more strategic goals.

Today, more than ever, international collaboration in research – as well as scientific and cultural diplomacy – constitutes an indispensable tool to tackle the major global challenges of our time. Given their nature and scale, these challenges demand a resolute, collective, and comprehensive approach.

To respond effectively to unprecedented transformations – such as climate change and the development of digital and energy twins – we must be prepared to offer solutions that are increasingly effective and based on diverse, integrated expertise.

We must embrace a multilateral vision focused on the co-creation of a sustainable future – one that aligns with the aspirations of the generations to come. Indeed, it is both for them and with them that we are working.

The Ministry of Universities and Research remains firmly committed to supporting the organisation of the Italy-China Week, convinced that it represents a powerful tool to fulfil this responsibility.

I would also like to highlight that Italy and China rank among the top five countries worldwide in terms of scientific publication output – a fact that demonstrates the strategic value both our nations place on research.

Science stands at the core of diplomatic relations between Italy and China, as Minister Yin – a highly esteemed scientist with a distinguished track record – has also pointed out.

This year marks the 55<sup>th</sup> anniversary of diplomatic ties between our countries, alongside the 20<sup>th</sup> anniversary of the Global Strategic Partnership established in 2004 by the Berlusconi government.

The recent State Visit to China by the President of the Italian Republic, Sergio Mattarella, earlier this month, is a powerful testament to the strength of the relationship between our two countries.

On that occasion, academic and scientific communities from both sides have come together to initiate a structured dialogue in the field of higher education – carrying forward the very same spirit that has animated the Science, Technology and Innovation Week for many years. This underscores our shared commitment to the exchange of knowledge and the integration of scientific expertise.

This year's discussions between Italian and Chinese experts will revolve around a broad yet targeted set of themes: the conservation of cultural and artistic heritage – especially through the application of artificial intelligence to cultural assets; food production and processing systems; advanced manufacturing; climate change and biodiversity; disaster risk reduction; the protection and restoration of coastal areas, seas, and oceans; and polar sciences.

These are not incidental choices – they are the result of careful consideration and are grounded in existing, well-established partnerships.

Allow me to cite just one illustrative example: in Antarctica, along the Ross Sea – the world's largest marine protected area – the Italian research station “Mario Zucchelli” stands just a few kilometres from the new Chinese polar research facility.

It is precisely in such remote and extreme environments that we are afforded a unique opportunity to show how collaboration not only enhances progress but is essential to the collective well-being of our planet.

In closing, I wish to underscore that none of this would have been possible without the tireless commitment and outstanding efforts of the Foundation IDIS-Città della Scienza, the National Research Council, Ca' Foscari University, the Ministry of Foreign Affairs and International Cooperation, the National Institute for Nuclear Physics, the Anton Dohrn Zoological Station, and all the other participating research institutions, universities, and national partners.

A sincere thanks also goes to the Ministry of Science and Technology of the People's Republic of China, the Beijing Municipal Science & Technology Commission, and the International Technology Transfer Network who worked with great dedication, together with the Ministry I have the honour of serving, to bring this event to fruition.

Investing in scientific research and advancing international cooperation remain the only true guarantees for a sustainable future.

Honourable Minister Yin, dear colleague, dear friends, I look forward to meeting you again in China next year.

I wish you all a productive and successful day. Thank you.



## MINISTER YIN HEJUN'S SPEECH

*Yin Hejun*

Minister of Science and Technology of the People's Republic of China

Honorable Minister Anna Maria Bernini, Ambassador Jia Guide, Chairman Riccardo Villari, distinguished guests, ladies and gentlemen, friends:

Good morning!

I am delighted to join you all at the Città della Scienza in Naples for the 13<sup>th</sup> China-Italy Innovation Cooperation Week. On behalf of the Ministry of Science and Technology of China, I extend my sincere greetings and a warm welcome to representatives from government departments, research institutions, universities, and enterprises of both China and Italy.

The history of exchange and cooperation between the peoples of China and Italy is long-standing. Since ancient times, China and Italy have been closely linked through rich cultural interactions. This year marks the 700<sup>th</sup> anniversary of the passing of Mr. Marco Polo. Over the past seven centuries, "The Travels of Marco Polo" has sparked the first China craze in the West, followed by generations of friendly envoys. This year also celebrates the 20<sup>th</sup> anniversary of the establishment of a comprehensive strategic partnership between China and Italy. Over the past two decades, our two countries have established the China-Italy Government Committee and held 11 joint meetings, continuously expanding friendly cooperation in various fields. In recent years, there has been frequent high-level exchange visits between our two countries. Chinese President Xi Jinping successfully visited Italy in 2019, and President Mattarella and Prime Minister Meloni have visited China this year, promoting our bilateral relations and people-to-people friendship to a new level.

Distinguished guests, scientific and technological cooperation is an essential component of the comprehensive strategic partnership between China and Italy. In 1978, our two countries signed an intergovernmental agreement on scientific and technological cooperation and have since held 17 joint committee meetings on science and technology cooperation, continuously enhancing the level of cooperation between our two nations.

In 2010, the Ministry of Science and Technology of China and the Italian Ministry of University and Research jointly established the China-Italy Innovation Cooperation Week to support exchanges and cooperation between researchers from both countries in numerous fields such as cultural heritage protection, green development, agriculture and food, health and medical care, disaster prevention and mitigation, advanced manufacturing, high-energy physics, and more, contributing to scientific exploration and the well-being of our peoples.

After an eight-year interval, the China-Italy Innovation Cooperation Week returns to Naples once again. Naples is a city with a long history and distinctive features in technological innovation. Researchers have used scientific methods and technological means to explore, protect, and restore Pompeii's artifacts, and have developed advanced emergency response systems and volcanic monitoring and early warning systems through earthquake tracking technology and volcanic activity prediction, making significant contributions to economic and social development.

Distinguished guests, China's development is inseparable from the world. In November 2023, China issued the "International Cooperation on Science and Technology Initiative." During the G20 Rio Summit in November this year, China, the African Union, Brazil, and South Africa jointly proposed the Open Science International Cooperation Initiative, advocating for the joint construction of a global innovation network to address global challenges and promote sustainable scientific and technological development.

Currently, the new global scientific and technological revolution and industrial transformation are accelerating, and both China and Italy face the task of optimizing industrial structures and promoting economic growth, with broad space for cooperation. Strengthening China-Italy scientific and technological innovation cooperation is the common desire and need of both countries and is also a key link in promoting the in-depth development of our bilateral relations.

The year 2025 marks the 55<sup>th</sup> anniversary of the establishment of diplomatic relations between China and Italy, as well as the 50<sup>th</sup> anniversary of the establishment of diplomatic relations between China and the European Union. It is a year of great significance for China-Italy and China-Europe cooperation. We hope that both sides will join hands to promote scientific and technological innovation cooperation and make greater contributions to the economic and social development of our two countries and to the building of a community with a shared future for humanity.

Finally, I wish the 13<sup>th</sup> China-Italy Innovation Cooperation Week a complete success. I also invite everyone to visit China next year for the 14<sup>th</sup> China-Italy Innovation Cooperation Week. Thank you all.

## **FORUM**



## THE CNR IN THE ITALY-CHINA WEEK: TEN YEARS OF SCIENTIFIC COOPERATION (2015-2024)

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### 1. Introduction

The *Italy-China Science, Technology and Innovation Week* is the leading institutional platform for bilateral scientific diplomacy. Since 2015, the National Research Council (CNR) has been a central actor in every edition, contributing with increasing intensity, scientific depth, and thematic diversification.

As co-coordinator of the program on the Italian side – together with Fondazione Idis – Città della Scienza – the CNR has helped shaping a multidisciplinary and innovation-driven ecosystem, promoting dialogue between research institutions, universities, and enterprises. Through its sustained involvement, the CNR has actively supported the strategic objectives of the *Week*, positioning itself as a pillar of Italy's long-term scientific engagement with China.

### 2. The Role of the National Research Council in the Italy-China Week of Science, Technology and Innovation

The scientific partnership between Italy and China is one of the most consolidated and dynamic pillars of bilateral scientific diplomacy. Based on a scientific and technological cooperation agreement first signed in 1978, the partnership has been progressively strengthened through a series of implementation instruments, including executive programs, joint research and mobility projects, thematic workshops, and joint initiatives in applied research, innovation, and technology transfer.

One of the most significant elements of this cooperation is the *Italy-China Science, Technology and Innovation Week*, established in 2011 and now in its thirteenth edition in 2024.

The National Research Council (CNR) has played a central role in the development and management of scientific relations with China. Through the signing of framework agreements, promotion of joint projects, and active participation in intergovernmental forums, the CNR has contributed to consolidating the systemic dimension of cooperation.

Its consistent presence in Italian delegations at the *Week* has ensured institutional, scientific, and programmatic continuity in relations with major Chinese research entities.

Its presence has grown over the years in terms of both the number of delegates involved and the level of coordination with partner Chinese institutions. The CNR has participated with multi-institute and multidisciplinary delegations, often made up of directors of institutes, researchers, and technology transfer managers, representing various scientific areas of excellence.

The CNR has contributed to strengthening the systemic role of the *Italy-China Week* by fostering the integration of scientific research with applied research and innovation. The presence of CNR researchers in B2B sessions, the organization of joint thematic workshops, and the promotion of multilateral initiatives have enabled the establishment of stable cooperation channels in frontier sectors.

Through its presence, the CNR has played a dual role:

- Institutionally, by contributing to the planning and management of bilateral agreements and strengthening scientific diplomacy by representing an authoritative voice in institutional panels and contributing to the definition of long-term strategic guidelines shared between the two governments.
- Scientifically, by coordinating the participation of research institutes in calls, projects, and scientific events.

### **3. Key Editions: Milestones of a Growing Collaboration**

#### *3.1 The 2015 Edition (Chongqing) – The First CNR Participation under President Nicolais*

The CNR's inaugural participation marked the beginning of a structured journey. The institution presented 12 joint research projects with Chinese partners and laid the groundwork for memoranda of understanding with CAS and Fudan University, as well as for a joint laboratory on chemistry and advanced materials at Sichuan University in Chengdu.

#### *3.2 The 2018 Edition (Milan and Naples) – The Contribution of President Inguscio*

Under the presidency of *Massimo Inguscio*, the CNR played a central role. The event hosted over 800 participants, including researchers and innovative companies. The CNR organized 6 thematic sessions, covering ICT, smart cities, robotics, and biotechnology. Collaboration with the Chinese Academy of Sciences was further formalized. "Science is a universal language: it builds bridges, not barriers."

### 3.3 *The 2021 Edition (Digital) – Science and Post-Pandemic Resilience*

During the pandemic, the CNR restructured its participation with 10 digital panels and 22 technical presentations. The newly appointed President, *Maria Chiara Carrozza*, highlighted the role of scientific research in sustainable reconstruction: “The ecological and digital transitions require strong scientific alliances and predictive tools based on reliable data.”

### 3.4 *The 2022 Edition (Beijing and Zhongguancun Forum) – New Challenges and Knowledge Governance*

The CNR actively took part in the Zhongguancun Forum, China’s flagship innovation event, with sessions on circular economy, advanced materials, and industrial cooperation. Contacts were initiated to establish a joint center on digital twins and climate modeling.

## **4. The 2024 Edition: Relaunch and Renewal**

Held between Naples and Venice, the 14<sup>th</sup> edition (26-28 November 2024) saw a CNR delegation of 7 researchers participating in 6 sessions. Key topics included:

- Resilient healthcare systems post-COVID
  - Marine biodiversity & deep sea exploration
  - AI for crop phenotyping
  - Cooperation on Arctic and Antarctic regions
- Among the most relevant outcomes:
- Proposal to renew the Memorandum of Understanding between the CNR and the Polar Research Institute of China (PRIC)
  - Signing of a new CNR-MOST Framework Agreement in Beijing (with Ambassador Massimo Ambrosetti)
  - Inclusion of the CNR in the working group for drafting the Italy–China roadmap on clean tech

### 4.1 *Summary of CNR Scientific Contributions at the Italy-China Week 2024*

As part of the 13<sup>th</sup> edition of the Italy-China Week of Science, Technology and Innovation, the National Research Council presented a wide and structured participation, addressing some of the most advanced frontiers of scientific cooperation between the two countries. Below is a summary of the thematic contributions presented.

### **Polar Sciences: Cooperation, Protection, and Observation**

Strengthening scientific collaboration in the Arctic and Antarctic emerged as a strategic focus. A Memorandum of Understanding was proposed between the CNR Institute of Polar Sciences and the Polar Research Institute of China to optimize infrastructures and synergies in climate research and the protection of the Ross Sea Marine Protected Area. Particular attention was given to the Arctic station *Dirigibile Italia* in Ny-Ålesund, an advanced example of a multidisciplinary observatory for the cryosphere, aerosols, and oceanic and biological dynamics of the fragile Arctic environment.

### **Advanced Manufacturing: Technology, Sustainability, and Industry 4.0**

Italy reaffirmed its role as a strategic industrial partner thanks to its leadership in European manufacturing. The session highlighted the integration of technologies such as robotics, additive manufacturing, artificial intelligence, Industrial IoT, and augmented reality for sustainable production. Opportunities for cooperation with China were discussed in the context of the 2024-2027 Strategic Action Plan, also as a response to the slowdown in global demand.

### **Natural Capital and Marine Biodiversity: Ecological Awareness as a Necessity**

Professor Ferdinando Boero emphasized the importance of biodiversity and the ocean for the functioning of planetary ecosystems. The concept of natural capital was proposed as the foundation for future economies, and widespread ecological literacy was highlighted as a necessary condition for any effective sustainable transition.

### **Advanced Phenotyping: Precision Agriculture and Artificial Intelligence**

Research led by CNR-IPSP Director Mauro Centritto demonstrated how phenotyping platforms, integrated with drones and high-precision sensors, can help identify crop varieties resilient to climate stress. The use of machine learning and deep learning techniques paves the way for a new predictive, intelligent, and sustainable agriculture, essential in addressing global water and food scarcity.

### **Food Systems: Sustainability, Digitalization, and Circularity**

Dr. Michelangelo Pascale presented key Italian projects in the field of food security and agri-food innovation (AGRITECH, ONFOODS, NBFC). The session covered essential topics such as circular agriculture, digitalization of supply chains, and protection of agricultural biodiversity. The dialogue with China aims to share technological strategies to make food production more resilient and traceable.

### **Climate Change and Biodiversity: Modeling, Observation, and Governance**

In a contribution coordinated by Dr. Stefano Pignatti, the focus was on Italy-China cooperation in observing and modeling climate change and biodiversity. Projects such as Dragon 6 (ESA-CNSA), the CNR-CAS partnership, and support from Città della Scienza helped to establish common networks. Presentations highlighted current limitations of observation systems, calling for the development of transnational networks and hybrid models based on AI to simulate ecosystem evolution.

### **5. Achievements (2015-2024)**

Over the past ten years, the CNR's participation has led to:

- 24 bilateral agreements and 5 joint laboratories
- Over 100 cooperative research projects
- 12 co-filed patents and 4 start-ups born from joint initiatives
- More than 250 co-authored scientific publications
- Over 80 mobility exchanges of young researchers in both directions

### **6. Future Perspectives: 2025-2030**

In line with global challenges and European priorities (Green Deal, Horizon Europe, Digital Compass), the CNR aims to:

- Strengthen cooperation on green hydrogen, advanced batteries, and superconductors
- Promote joint laboratories on quantum communication and photonics
- Launch a three-year mobility program for young talents
- Collaborate on the development of digital twins for environmental monitoring
- Develop joint activities in marine sciences, Antarctic research, and deep ocean technology

Special attention will be given to promoting gender equality in research, ensuring the ethical use of AI, and protecting intellectual property in joint projects.

### **7. Conclusions**

The participation of the CNR in the *Italy-China Science, Technology and Innovation Week* has acted as a driving force for the internationalization of Italian public research, as well as an effective tool for building strategic relations with one of the world's leading scientific powers.

In a context marked by environmental, technological, and geopolitical transitions, scientific cooperation remains essential to ensure shared, sustainable, and inclusive development. The decade 2025-2035 will be crucial for consolidating the achievements made and

expanding the pathways of Italy-China collaboration, turning global challenges into opportunities through the transformative power of joint scientific endeavour.

## **FORUM 1**

### **Conservation of Artistic and Cultural Heritage**



## NEW CHALLENGES FOR THE MANAGEMENT AND ENHANCEMENT OF TANGIBLE AND INTANGIBLE HERITAGE

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**Keywords:** digital transition, cultural heritage valorisation, artificial intelligence, intangible heritage, international cooperation

Digital transition and climate change represent complex challenges that require a broad and shared vision, even in decisions concerning the safeguarding and valorisation of cultural heritage<sup>1</sup>. We can no longer face the trials of the coming years with isolated, limited, or regionally confined interventions. Instead, it is necessary to work at a transnational level to develop inclusive global strategies capable of transcending territorial boundaries and designing large-scale, reasonable solutions. Emerging technologies can play a key role in this endeavour, offering tools to develop a new culture that simultaneously ensures the conservation, accessibility, and sustainability of both tangible and intangible cultural heritage<sup>2</sup>. This challenge has already been embraced by China and Italy, whose decade-long collaboration represents a concrete example of how international dialogue can operate positively and facilitate, through open communication, the continuous exchange of virtuous experiences and best practices that mutually enrich both parties.

The tangible prospects offered by the growing adoption of Open Science principles are driving researchers and professionals toward the creation of supranational research spaces that foster the emergence and consolidation of interdisciplinary collaborations aimed at the growth and defence of cultural heritage<sup>3</sup>. Governments are also particularly active in promoting policies that support effective digital transformation, developing strategies useful for achieving the goals of truly open and shared knowledge.

Artificial intelligence and, more broadly, technologies within the domain of Digital Humanities are opening new scenarios for research, safeguarding, and the management

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<sup>1</sup> RUSSO SPENA, BIFULCO 2021.

<sup>2</sup> MIŁOSZ, KESIK 2024.

<sup>3</sup> ROUED-CUNLIFFE 2020.

of artistic, architectural, and archaeological heritage<sup>4</sup>. The new challenges we are called to address are gradually revolutionizing artisanal and professional sectors that encompass knowledge rooted in rich and well-established traditional cultures. Areas such as diagnostics, restoration, monitoring, and valorisation are increasingly relying on artificial intelligence techniques and the opportunities offered by computer graphics, providing innovative immersive experiences. Analyses of paintings, frescoes, statues, and even large monuments and entire residential complexes can now be effectively conducted by computers capable of suggesting reconstructive hypotheses while simultaneously supporting virtual restorations<sup>5</sup>.

However, the spread of computational techniques must not overshadow the philological approach and sensitivity in the study of antiquity that allows us to look to the past as an inexhaustible reservoir from which to draw new knowledge. The risk, on the contrary, is delegating the entire process of historical-artistic analysis and reconstruction to digital techniques, particularly artificial intelligence, with the danger of falling into the trap of so-called hallucinations.

The inclusion of a specific panel dedicated to the frontiers of artistic and cultural heritage conservation within the framework of the 13<sup>th</sup> Italy-China Week has fostered dialogue between Italian and Chinese researchers on the themes of technological innovation and the protection of cultural heritage, further consolidating the strategic global partnership that has linked the two nations for over two decades.

The new challenges posed by industrial, productive, and social transformations require attention to the protection and valorisation of not only material but also intangible heritage, as well as the de-functionalization and re-functionalization of large monuments by institutions interested in enhancing the cultural and touristic offerings of even disadvantaged territories. The paradox of this growth lies in the increased environmental risks and dangers generated by uncontrolled mass tourism, which threatens to overwhelm both small and large communities<sup>6</sup>. To monitor the risks of overtourism and, more generally, the increase in pollution caused by industrial growth, digital technologies can offer innovative solutions through the use of sensors capable of analysing tourist flows in real time while simultaneously monitoring potential anthropogenic or environmental hazards. Non-invasive sensor technology can also play a significant role in improving conservation techniques for ancient artifacts made of different materials and in various contexts, revolutionizing traditional restoration and conservation methodologies, which can also benefit from advanced material nanotechnology<sup>7</sup>.

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<sup>4</sup> RUTHVEN, CHOWDHURY 2015.

<sup>5</sup> THIEL, BERNHARDT 2024.

<sup>6</sup> CHICA-OLMO *et al.* 2024.

<sup>7</sup> LAOHAVIRAPHAP, WAROONKUN 2024.

In terms of cultural and artistic heritage management, digital technologies open new scenarios by providing tools for the creation of digital cultural ecosystems. These ecosystems function as open spaces where a plurality of actors can freely access and draw information about material and intangible heritage, thereby promoting more inclusive sharing and valorisation<sup>8</sup>.

The various presentations by scholars during the 13<sup>th</sup> Italy-China Week highlighted some of the most significant national initiatives, showcasing best practices, scientific achievements, and novel research perspectives, including new forms of international cooperation. In particular, the role of citizens in protecting and enhancing practices related to intangible heritage emerged as crucial for the development of integrated policies for industrial planning and environmental sustainability. For example, national cultural parks, an original Chinese concept, encompass the protection of ecosystems and cultural resources and are based on community involvement, which is entrusted with the responsibility of transmitting spiritual, civil, and material heritage.

Thus, the digital transition plays a central role in safeguarding an ecosystem where the artistic, historical, and archaeological components of heritage merge with technological innovation. The key tools of this process, characterized by digitization and more modern management of cultural resources, are intelligent transformation and creative regeneration, which can unlock the economic value of archives and artistic data.

Digital technologies, artificial intelligence, Big Data, and the Internet of Things offer new forms of exploration, immersion, and perception of cultural heritage that transcend the rigid constraints of traditional museum experiences and preservation policies. At the same time, however, we must not abandon the culture and practices of conservation that can mitigate the dangers posed by climate change, even by resorting to innovative monitoring techniques such as those derived from satellite image analysis.

In conclusion, the 13<sup>th</sup> Italy-China Week provided a valuable opportunity to listen to proposals and general ideas, compare best practices in the protection, preservation and enhancement, and utilization of material and intangible heritage, and promote new institutional mechanisms while improving policies related to education and international collaboration.

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<sup>8</sup> CASSIA, CASTELLANI, ROSSATO 2023.

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# CHINA'S GRAND CANAL INTANGIBLE CULTURAL HERITAGE PROTECTION AND INHERITANCE RESEARCH

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**Keywords:** grand canal cultural heritage, intangible cultural heritage, heritage policy and governance, digital preservation, community-based heritage revitalization

## 1. Characteristics and Value of China's Grand Canal Intangible Cultural Heritage

The Grand Canal of China, along with the Great Wall, is renowned as one of the two great engineering feats of ancient China. With a history spanning over 2,500 years, the Grand Canal is a collective term for three canals: the Sui and Tang Grand Canal<sup>1</sup>, the Beijing-Hangzhou Grand Canal<sup>2</sup>, and the East Zhejiang Grand Canal<sup>3</sup>. In 2014, it was inscribed on the World Heritage List. Stretching nearly 3,200 kilometers, it flows through Beijing, Tianjin, Hebei, Shandong, Henan, Anhui, Jiangsu, and Zhejiang provinces (municipalities), encompassing 25 prefecture-level cities. The Grand Canal (Beijing section) was historically part of the “Sui and Tang Canal” and the “Beijing-Hangzhou Canal”.

### 1.1 *Concept and Categories of Grand Canal Intangible Cultural Heritage*

Most scholars believe that the intangible cultural heritage (ICH) of the Grand Canal should refer to the intangible cultural heritage directly or indirectly related to the Grand Canal, mainly including folk literature, performing arts, traditional handicrafts, traditional festivals and rituals, and production and life experiences associated with the Grand Canal. Generally, all ICH along the Grand Canal region is considered part of the Grand Canal ICH. The key characteristics of Grand Canal ICH are as follows:

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<sup>1</sup> Starting construction in 486 BC, with Luoyang as the center, it extended north to Zhuojun Prefecture (Beijing) and south to Yuhang (Hangzhou).

<sup>2</sup> Since the Yuan Dynasty, based on the Grand Canal of the Sui and Tang Dynasties, it was straightened and reconnected, linking the north and south of China, with Beijing as its vital hub.

<sup>3</sup> The Grand Canal from Hangzhou to Ningbo.

1. Openness and Cohesiveness: The Grand Canal of China runs through the country from north to south without distinct boundaries, the regions along the canal share similar spiritual and behavioral activities, and the Grand Canal ICH reflects the openness and cohesiveness of the local canal culture.
2. Regionality and Ecology: The Grand Canal ICH is closely related to the lifestyles and habits of the people living along the canal, while also being influenced by various ecological factors such as natural, social, and human factors. For example, the “boatmen’s songs” originated from the canal, and due to different accents in the north and south, the tunes vary across different canal sections.
3. Diversity and Unity: It reflects the characteristics and diversity of ICH in different regions, as well as the commonalities and unity related to the canal, showcasing the sense of identity and belonging to the canal culture shared by people along the canal. Examples include the ICH performance items that connect the north and south, such as Kunqu Opera, Guqin (ancient zither), and Shangyang Dance.
4. Inclusiveness and Harmony: The rich cultural activities along the Grand Canal have not only broadened people’s horizons but also promoted material and cultural exchanges between different regions, fostering mutual exchange and integration among the Yan-Zhao, Qi-Lu, Central Plains, Wu-Yue, and Jing-Chu cultural regions.

### 1.2 Value of Grand Canal Intangible Cultural Heritage

1. Core Values: They determine the characteristics of canal culture, including historical, cultural, and spiritual values.
2. Inherent Values: They embody the elements of the Grand Canal ICH itself, including artistic, technological, and educational values.
3. Extrinsic Values: They are formed through the development of the core and inherent values of the Grand Canal ICH, reflecting its practical value in the current era, including political, economic, and social values.



Fig. 1. Value System of the Grand Canal Intangible Cultural Heritage.

Extrinsic Values	Extrinsic Values	Political, economic, and social values
Inherent Values	Inherent Values	Artistic, technological, and educational values
Core Values	Core Values	historical, cultural, and spiritual values

Table 1.

## 2. Overview of the Protection and Inheritance of China's Grand Canal Intangible Cultural Heritage

### 2.1 *Strong Government Commitment and Policy Framework*

#### 2.1.1 National-level Policies

In 2019, the General Office of the CPC Central Committee and the General Office of the State Council issued the “Outline for the Protection, Inheritance and Utilization of the Grand Canal Culture”, clearly stating that “the protection and inheritance of the Grand Canal intangible cultural heritage” is one of the cultural heritage protection and exhibition projects. In 2020, the Ministry of Culture and Tourism and the National Development and Reform Commission jointly issued the “Plan for the Integration of Grand Canal Culture and Tourism Development”. In 2021, the National Development and Reform Commission issued the “Implementation Plan for the Protection, Inheritance and Utilization of the Grand Canal Culture during the 14<sup>th</sup> Five-Year Plan Period”.

#### 2.1.2 Provincial-level Policies

In 2019, Beijing released the implementation plan and five-year action plan (2018-2022) for the protection, inheritance, and utilization of the Grand Canal culture. In 2022, the standing committees of the people's congresses in Beijing, Hebei, and Tianjin successively passed the “Decision on Coordinated Promotion of the Protection, Inheritance and Utilization of the Grand Canal Culture in the Beijing-Tianjin-Hebei Region”. Zhejiang, Jiangsu, and other provinces have also successively issued implementation plans for the protection, inheritance, and utilization of the Grand Canal culture, as well as regulations for the protection of the Grand Canal World Cultural Heritage site.

## 2.2 Current Status of ICH Protection and Inheritance Along the Grand Canal

Significant progress has been made in the protection of ICH items along the Grand Canal. As of now, the eight provinces (municipalities) along the Grand Canal have a total of 1,157 national-level intangible cultural heritage protection items, as well as numerous provincial and municipal-level ICH items.

Unit: Item						
Province (Municipality)	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Total
<b>Beijing</b>	12	60	15	15	18	120
<b>Tianjin</b>	7	10	5	11	14	47
<b>Hebei</b>	39	78	15	16	14	162
<b>Shandong</b>	27	93	33	20	13	186
<b>Anhui</b>	26	34	14	14	11	99
<b>Henan</b>	26	56	13	18	12	125
<b>Jiangsu</b>	37	62	27	19	16	161
<b>Zhejiang</b>	46	97	60	30	24	257

Table 2. Number of Representative National-level Intangible Cultural Heritage Items in the Eight Provinces (Municipalities) Along the Grand Canal.

Various forms of ICH protection and transmission have been implemented along the Grand Canal:

- ICH + Grand Canal Museum Model: Such as the Beijing-Hangzhou Grand Canal Museum in Hangzhou, which has a dedicated intangible cultural heritage exhibition hall to introduce and showcase local ICH items.
- ICH + Professional ICH Bases: Using ICH clusters as carriers, focusing on improving the industrialization level of ICH and promoting the integration of ICH with the tourism industry.
- ICH + ICH Museum Model: Such as the dedicated ICH museum in Suzhou, which not only exhibits the representative works of national-level ICH inheritors but also showcases related derivative products and artistic creations.

### *2.3 Challenges Facing the Protection and Inheritance of the Grand Canal Intangible Cultural Heritage*

Institutional mechanisms need to be improved. Cultural heritage protection along the canal is generally carried out in a segmented manner, with each region planning and managing independently, lacking cross-regional, cross-departmental, and cross-industry cooperation mechanisms.

- Insufficient participation of social forces. The current ICH protection work mainly relies on fiscal support, with little involvement of social funds. Large-scale ICH events are generally organized by the government, and other small and medium-sized events also rely on government initiatives, with relatively weak spontaneous organizational abilities from the public.
- Pressure on the continuation of ICH inheritors. The production and living environments of ICH inheritors face various difficulties. Due to economic constraints, many inheritors lack even workspace, and many ICH projects struggle to attract apprentices.
- Need for strengthened research on the Grand Canal ICH. The concept, connotation, and related statistical data of the Grand Canal intangible cultural heritage need to be further explored. Moreover, with the changing times, many intangible cultural heritage items, such as the “boatmen’s songs” of the canal, have become detached from modern life, and lost their original social and cultural environment. Additionally, people’s cultural concepts, aesthetic abilities, and appreciation levels have also undergone significant changes. The issue of revitalization and utilization of ICH needs to be addressed through research.

## **3. Thoughts and Strategies for Promoting the Protection and Inheritance of the Grand Canal Intangible Cultural Heritage**

### *3.1 General Thoughts*

To strengthen the overall protection of intangible cultural heritage (ICH) in the Tongzhou section of the Grand Canal, several integrated approaches are essential. First, ICH protection must be closely linked with the preservation of tangible cultural heritage, as intangible heritage relies on specific spaces and domains provided by tangible heritage. Additionally, safeguarding the ecological environment of the Grand Canal is crucial to support the ICH associated with it. Effective protection requires a coordinated effort among administrative departments, academia, businesses, and other sectors of society, with active participation from the public. Finally, enhancing public cultural facilities, such as museums and cultural centers, is vital to fostering the preservation and promotion of ICH in the region.

To balance the protection, inheritance, and utilization of the Grand Canal ICH, certain strategic considerations need to be advanced. First, promote utilization through protection and inheritance. The Grand Canal ICH should not be approached as static cultural relics, requiring full preservation or exact restoration; instead, moderate adaptation and creative renewal should be permitted; moderate selection, elimination, and innovation are allowed. Equally promotes protection and inheritance through utilization. ICH protection is strengthened by continued engagement and use. By continuous utilization while maintaining its authenticity, the motivation of all sectors of society for its protection can be stimulated. Lastly, promote the protection and utilization of the Grand Canal ICH through innovative systems and mechanisms: enhance the innovative awareness and capability of ICH inheritors, establish platforms for the protection and development of canal ICH, support and encourage innovation in cultural products related to canal ICH.

### *3.2 Policy Recommendations*

1. Formulate local regulations for the protection of the Grand Canal cultural heritage and actively construct a coordination mechanism for the protection and inheritance of the Grand Canal intangible cultural heritage. Strengthen cooperation and coordination with neighboring provinces and cities.
2. Establish a “Grand Canal Intangible Cultural Heritage Cooperative Development Alliance”. Encourage districts, industry associations, and social organizations to establish cross-regional, cross-departmental, and cross-industry cooperative organizations to carry out work related to the protection and utilization of the Grand Canal ICH.
3. Strengthen the inheritance and innovation of the Grand Canal ICH and integrate it into modern life. For example, transform the “boatmen’s songs” and “canal dragon lanterns” into operas, stage plays, etc., allowing the public to experience the charm of ICH.
4. Enhance the digitalization and informatization of the Grand Canal intangible cultural heritage and strengthen the construction of digital databases.
5. Increase support for ICH inheritors.
6. Strengthening talent development. It is recommended to offer relevant ICH training courses in vocational art schools and strengthen the cultivation of ICH cultural talents, design talents, technical talents, and management talents.
7. Leverage the role of think tanks, experts, and university-based intangible cultural heritage research bases to conduct relevant research and enhance the scientific and effective nature of the Grand Canal ICH protection, inheritance, and utilization.
8. Establish a Grand Canal Intangible Cultural Heritage Research Association and create an academic exchange platform.

9. Promote the construction of infrastructure such as Grand Canal ICH exhibition halls to create spatial platforms for the protection and inheritance of the Grand Canal ICH.
10. Establish platforms for public participation in ICH protection, such as the “Grand Canal ICH Exhibition” and “Grand Canal Cultural Festival”. Promote the Grand Canal ICH in schools, communities, villages, enterprises, and news channels, expanding the dissemination channels of the Grand Canal.

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# RESEARCH ON THE INTERPRETATION AND DISSEMINATION OF CULTURAL VALUES IN THE GREAT WALL NATIONAL CULTURAL PARK

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**Keywords:** Great Wall National Cultural Park, the cultural value of the Great Wall, cultural heritage

National cultural parks differ from national parks in that their distinctive feature lies in the exploration and dissemination of cultural values. The Great Wall is hailed as “a symbol of Chinese civilization and the spirit of the Chinese nation”. The construction of the Great Wall National Cultural Park aims to create an important symbol of the Chinese nation, protect and inherit outstanding traditional culture, and consolidate a powerful spiritual force. As time and space have evolved, the Great Wall has become detached from its original historical and social context. It has lost its practical use value and has become distant from contemporary times and society. Therefore, in the new era, the cultural values embodied by the Great Wall need to be re-explored, interpreted, and disseminated to construct contemporary common values for the nation and all of humanity. In light of this, this paper attempts to delve into the cultural values of the Great Wall, interpret their meanings, and propose strategies for their dissemination.

## 1. The Cultural Value of the Great Wall as an “Objective Entity”

The essence of humanity is manifested through the things that humans create. The Great Wall is a rare largescale linear military defense system in human history, representing the practical response and great creation of historical individuals to the issues of war and peace. It is recognized as “one of the four greatest ancient engineering feats in the world”<sup>1</sup>, embodying the “unrelenting vitality of the Chinese people”.

The construction of the Great Wall began during the Spring and Autumn period, with various vassal states building continuous defensive walls along their borders. This describes the construction of the Great Wall (wall) as a military defense by the state of Qi. After the

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<sup>1</sup> MENG 2020.

unification of China, the Qin Dynasty repaired the remaining walls from the Warring States period and expanded and connected them to form a defense system, which continued into the Han Dynasty. Subsequently, almost every dynasty engaged in the construction of defense structures. The Great Wall, spanning over 2,000 years, records, preserves, and bears witness to the development of Chinese civilization. According to a survey by the National Cultural Heritage Administration, the remains of the Great Wall in China span 404 counties (cities, districts) across 15 provinces and regions, including the Warring States, Qin, and Han Great Walls, as well as defense facilities with characteristics of the Great Wall from the Northern Wei, Northern Qi, Northern Zhou, Sui, Tang, Five Dynasties, Song, Western Xia, and Liao dynasties, along with the Jin Dynasty's boundary trenches and the Ming Great Wall.

In 1987, the Great Wall was listed by UNESCO as one of China's first World Heritage Sites. The cultural value of the Great Wall is reflected in the authenticity of its cultural heritage. Firstly, it is based on the authenticity of the object itself, which is a tangible physical state, including defense facilities such as walls, fortresses, towers, and beacon towers, as well as natural landscapes formed by the combination of earth mounds, stone piles, and various terrains such as coastal areas, mountains, valleys, plateaus, and plains. As an objective entity, the Great Wall holds cultural value in terms of architecture, military science, and history, and, due to its visibility (perceptibility), it also holds aesthetic cultural value. Even an individual who is completely unaware of the historical function and cultural significance of the Great Wall can experience a profound impact, from visual to emotional, by being in the presence of the Great Wall and gazing upon its majestic form and the magnificent scenery formed by its surroundings. In other words, even if one strips away its historical and cultural connotations, the Great Wall, as a purely physical entity, can still convey to individuals a sense of human creativity and subjectivity, a sense of "universal human essence that transcends nationality, identity, ideology, and regional factors"<sup>2</sup>, and a sense of the unity of human values.

## **2. The Great Wall as a Symbol of Cultural Value**

According to the Oxford English Dictionary's definition of authenticity in cultural heritage, authenticity encompasses not only the physical object itself but also the emotions, meanings, and other abstract symbols associated with it. For the Chinese nation, the Great Wall is a "monument to cultural identity and spirit"<sup>3</sup>, a symbol of national culture that has been imbued with emotion and meaning over the long course of history, embodying the unique values and spiritual qualities of the Chinese people<sup>4</sup>. The Great Wall is both an internal

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<sup>2</sup> MENG 2020.

<sup>3</sup> FU 2021.

<sup>4</sup> YAO 2016.

identity for the Chinese people and an external marker of the Chinese nation recognized by the international community.

As a military defense project, the Great Wall's function was to protect the homeland, life, and civilization, rather than to engage in external aggression. Its purpose was to prevent war and promote peace. Historically, Chinese civilization rarely initiated wars and almost never engaged in land conquest or colonization, fully reflecting the peace-loving nature of the Chinese people<sup>5</sup>. The unification of the six states' walls by the Qin Dynasty served both to defend against external aggression and to promote internal national cohesion and the continuation of civilization. Sun Yat-sen, in his "Plan for National Construction", commented that without the Great Wall, the prosperity of the Han and Tang dynasties would not have been possible, and the subsequent integration and development of Chinese culture would not have occurred. Over the past two thousand years, the Great Wall has been associated with the nation, ethnicity, politics, military, culture, and commerce, appearing in historical documents, cultural works, artistic achievements, and academic thought. As a cultural symbol, it has been formed, accumulated, evolved, and strengthened in the collective memory of generations of Chinese people, contributing to the assimilation of the Chinese nation.

The Great Wall truly "became a spiritual symbol of the Chinese nation in the face of external threats in modern times". During the modern era, when faced with the invasion of colonial powers, the Chinese people's national consciousness and spirit were strengthened. The cultural value of the Great Wall evolved into a spiritual driving force for the Chinese nation to resist foreign invasion. Sun Yat-sen, in his "Plan for National Construction", identified the Great Wall as a symbol of the Chinese nation's resistance to foreign powers. After the "September 18 Incident", the Great Wall further became a psychological Great Wall that united the will of the entire nation. Tian Han, in his creation of the "March of the Volunteers" for the film "Children of Troubled Times", wrote: "With our flesh and blood, we will build our new Great Wall...", the song became the anthem of China. The Great Wall embodies the way of thinking and labor wisdom of the ancient Chinese people in defending peace, carries the unyielding spirit and enduring strength of the Chinese people, and embodies the cultural value and identity of the Chinese nation.

The evolutionary pattern of the Chinese nation's diversity in unity, the spiritual characteristics of Chinese civilization, carrying forward the common values for all mankind contained in Chinese civilization is one of the important functions of national cultural parks.

Historically, the Great Wall region was the place where the Central Plains culture and grassland culture, as well as the farming civilization and nomadic civilization, were separated

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<sup>5</sup> Ji 1994.

and clashed with each other. It was also a place for exchanges and integrations<sup>6</sup>. It was the starting area of the Chinese nation's diversity in unity as described by Fei Xiaotong<sup>7</sup>. The construction of the Great Wall avoided large-scale wars and also formed a pattern of cultural exchanges between the north and the south with the Great Wall as the center<sup>8</sup>. From King Wuling of Zhao, who advocated "wearing the Hu-style clothing and shooting on horseback" when building the Zhao Great Wall during the Warring States Period, to the historical facts reflected by the preserved sites and unearthed cultural relics along the Great Wall in the Qin and Han Dynasties, the Northern and Southern Dynasties, the Liao, Jin, Yuan Dynasties and the Ming Dynasty, all have proved that the Great Wall has always served as a bond for cultural dialogue and exchanges in cultural terms. The customs and horse markets along the Great Wall were not only the markets for peaceful trade between the feudal dynasties in the Central Plains and the northern nomadic peoples but also the post stations for cultural exchanges.

The Great Wall also plays an active role in the exchanges and mutual learning between Chinese and Western cultures. Another important purpose of building beacon towers and fortifications in the Western Regions during the Western Han Dynasty was to open up channels for exchanges with the West<sup>9</sup>. The beacon towers and fortifications outside the Great Wall provided accommodation, transportation and military protection for the formation of the "Silk Road", and became the traffic and supply lines where Chinese culture met and interacted with Indian culture, Greek culture and Persian culture. Cultural diversity has been enriched and strengthened in the contact of different cultures. Therefore, the cultural value of the Great Wall is also manifested in its inclusiveness of different civilizations, exchanges and mutual learning.

In general, the Great Wall is an objective manifestation of the continuous history and vitality of the Chinese nation and all mankind. It is a commemorative symbol that confirms the history of the Chinese nation and all mankind. It is an identity symbol of the Chinese nation, reflecting the cultural tradition of the Chinese nation that values harmony, and embodying the common values of all mankind contained in Chinese civilization, that is, using cultural exchanges to transcend cultural barriers, using cultural mutual learning to transcend cultural conflicts, and using cultural coexistence to transcend cultural superiority.

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<sup>6</sup> DONG 2020.

<sup>7</sup> HAN, REN 2022.

<sup>8</sup> HAO, OU 2022.

<sup>9</sup> FU 2021.

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# THE PROTECTION OF ITALIAN CULTURAL HERITAGE FROM NATURAL RISKS IN THE CLIMATE CHANGE CONTEXT

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**Keywords:** climate change, cultural heritage preservation, natural hazards, remote sensing, risk mitigation

ISPRA (Italian National Institute for Environmental Protection and Research) is one of the leading national institutions for research and monitoring of natural risks threatening both natural and cultural heritage, particularly those triggered by meteorological and climatic forces. The institute provides technical and scientific support to the Italian government and participates in international initiatives for the protection of cultural heritage from geological and climatic risks. Its work encompasses the collection and analysis of environmental data, as well as the drafting of guidelines for damage prevention and mitigation. As a technical support body for ministries and territorial governmental agencies, ISPRA closely collaborates with Civil Protection, academic and research institutions, and associations to develop analysis and monitoring methodologies aimed at securing and reducing risk exposure.

## 1. Climate Change in Italy

Italy is geographically complex, characterized by a combination of natural and anthropogenic factors that make its cultural heritage particularly vulnerable ongoing environmental changes. The years 2023 and 2024 were the hottest on record, with thermal anomalies severely affecting the entire Mediterranean region, and Italy in particular.

In recent decades, average temperatures in Italy have risen significantly, accompanied by increasingly intense and frequent heat waves. These climatic anomalies lead to a higher incidence of extreme events such as heavy rainfall and prolonged droughts, which affect the stability of cultural heritage, significantly alter the natural, human, and infrastructural environment. These conditions contribute to the deterioration of frescoes, sculptures, and historic building materials, compromising their integrity, authenticity, and long-term survival. Climate change is altering biological cycles and geomorphological dynamics in

the short term, with potentially irreversible effects in the long term, such as landslides, subsidence, glacial and periglacial melting, and coastal instability. Therefore, continuous monitoring and the development of predictive models are essential for understanding these trends and implementing effective conservation strategies.

The specific impact of climate change on cultural heritage varies across both spatial and temporal scales, depending on the type of threat.

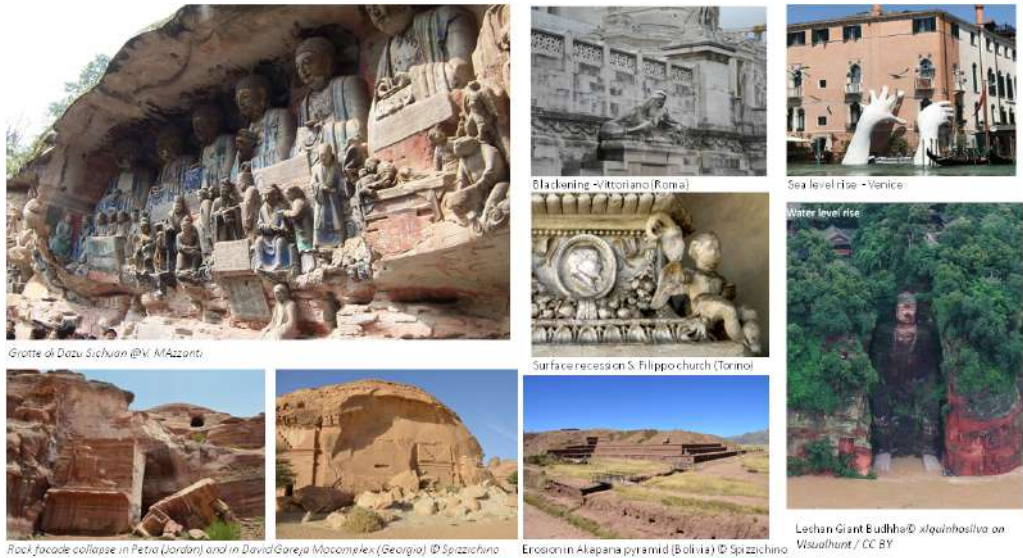


Fig. 1. Direct and indirect impacts of natural and anthropogenic effects induced by climate change on Cultural Heritage.

In areas where cultural heritage is concentrated (exposure), large-scale phenomena over longer temporal scales include instability, collapses, widespread erosion, sea level rise, coastal line stability, and hydraulic phenomena. On the micro-scale, issues such as weathering, blackening, stone recession, humidity, and capillary rise are observed.

Natural risks, ongoing meteorological and climatic trends, combined with urbanization, air pollution, and human activity, exacerbate conservation challenges. Italy is home to 60 UNESCO sites, over 220,000 cultural assets, 21 MAB (Man and the Biosphere) areas, and 12 geoparks, many of which are continuously exposed to natural hazards due to country's geography and history. ISPRA regularly maps these risks to identify the most vulnerable areas and prioritize in-depth analyses and mitigation funding.

Mountainous and hilly areas, with their widespread historic villages and town centers, are particularly prone to landslides, while cities of art, such as Florence and Rome,

risks from hydraulic hazards and structural degradation caused by air pollution. In Venice, rising sea levels and exceptional tides pose increasing threats. Heavy rainfall and unstable terrain contribute to landslides, endangering historic buildings of great value. In regions such as Calabria, Sicily, Puglia, Liguria, and Campania, coastal erosion threatens numerous cultural assets near the sea (see Figure 2).

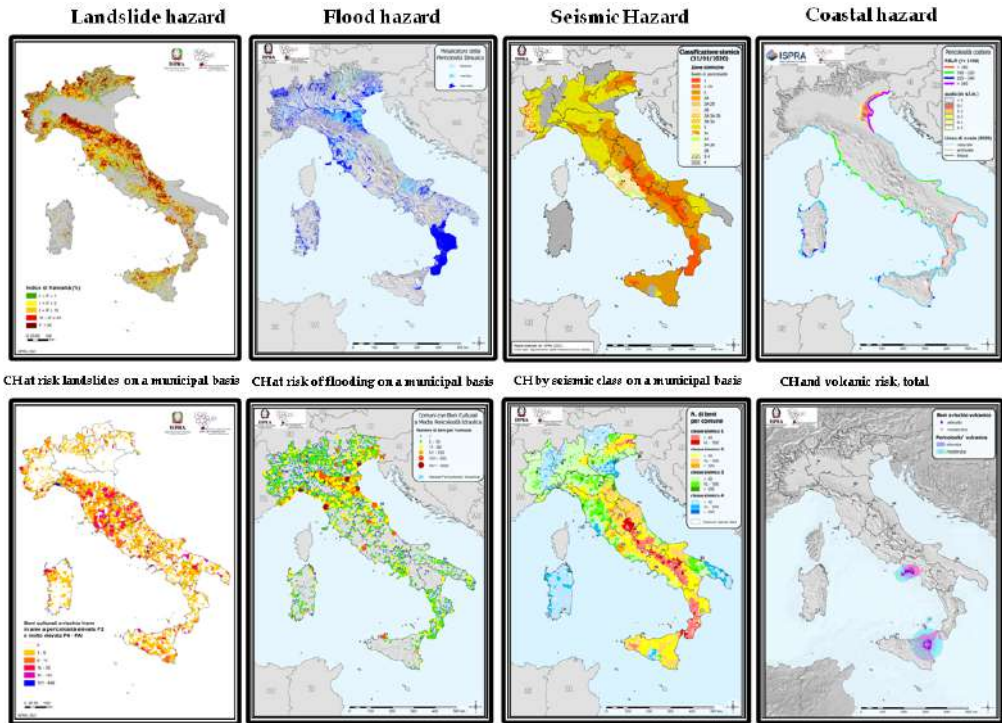


Fig. 2. Natural hazards and Italian Cultural Heritage at risk.

Additionally, seismic and volcanic hazards are widespread across Italy: more than 92,000 cultural assets are located in high seismic risk zones, and over 4,000 are exposed to volcanic hazards, particularly in areas surrounding Mount Etna and the Phlegraean Fields. Recent seismic events, such as those affecting central Italy in 2016, have highlighted the extreme vulnerability of historical and artistic heritage.

## 2. Advanced Technologies for Cultural Heritage Protection

ISPRA has long employed advanced technologies such as satellite remote sensing, for the structural monitoring of cultural assets. Techniques like radar interferometry enable the detection of ground movements and early signs of instability. These data, products, and services are essential tools for continuous, high-precision monitoring, supporting targeted interventions for the protection of high-risk sites.

Italy and China have collaborated for years on the study of natural risks affecting cultural heritage. The similarities in the types of heritage and the risk and the nature of the threats they face offer a valuable opportunity to develop shared conservation and risk mitigation strategies.

The future of cultural heritage conservation in the context of ongoing climate change depends on the integration of advanced technologies and strengthened institutional cooperation. ISPRA is actively working to enhance monitoring systems and promote international data sharing. The adoption of artificial intelligence and big data analytics is expected to revolutionize how cultural heritage is monitored and safeguarded. Continued investment in research and innovation is essential to ensuring the protection of cultural assets for future generations.

Safeguarding Italy's cultural heritage can no longer be postponed. Climate change is accelerating degradation processes that seriously threaten the integrity of historical and archaeological sites. The adoption of integrated management strategies, supported by cutting-edge monitoring technologies, represents the most effective path to ensuring the protection and sustainable enhancement of this extraordinary heritage.

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### **Useful Websites**

European Precipitation Indicators.

Europe’s Changing Climate Hazards.

Climate Copernicus.

ISPRA Landslide Viewer.

ISPRA Tsunami Map.

ISPRA Hydrogeological Risk App.



# DIGITAL INTELLIGENCE EXPLORATION: DECODING CULTURAL DATA FROM A DESIGN PERSPECTIVE

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**Keywords:** intangible cultural heritage, digital cultural ecology, AI-driven design, cultural big data, intelligent creativity

Hunan University, originating from the Yuelu Academy established in 976 A.D., is one of the oldest and most renowned and influential universities in China. Among its schools, the School of Design stands as one of the most representative and influential faculties. In 2006, the school was named one of the 60 best design colleges worldwide by Business Week, and in 2023, it was rated as a Class A subject in the national assessment, ranking among the top five in China. Since 2011, leveraging the Sino-Italian Design Innovation Center, the school has maintained close collaborations with the Italian design communities in areas such as scientific research, talent cultivation, and industrial services.

This research is derived from the NewChannel Design and Social Innovation project that has been actively run since 2009<sup>1</sup>. Deeply rooted in rural areas, the project team conducted field investigations in the Dong, Tibetan, Mongolian and other minority communities in western China, collected a substantial amount of first-hand data of local intangible cultural heritage (ICH) resources, fully explored the relationship between cultural resources, cultural industries and new technologies (Fig. 1).

The practical experience gained from this project enables us to approach ICH from a local, systematic, and sustainable perspective. Since the 1990s, “cultural digitization” has developed rapidly around the world<sup>2</sup>. Entering the era of digital civilization with the deep integration of culture and technology<sup>3</sup>, in fact, the digital construction, dynamic transformation, and crowd-intelligent innovation of ICH have become hotspots in intercultural and interdisciplinary research. However, the inheritance and innovation of ICH faces more complex and unforeseen challenges, such as fragmentation, homogenization

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<sup>1</sup> WANG *et al.* 2016.

<sup>2</sup> KHAN *et al.* 2018, 1-16.

<sup>3</sup> ASTAFYEVA *et al.* 2018, 516-531.



Fig. 1. Practice Roadmap of NewChannel project in rural China.

Image source: Drawn by the author.

and inefficiency<sup>4</sup>. Therefore, how to effectively leverage digital intelligence technology to create a multi-dimensional, interconnected and symbiotic digital-cultural ecology of ICH is the current general trend and key task.

In response to the growing integration of digital and intelligent technologies, through the design ecology methods, this study builds a comprehensive system covering resource collection, management, creation and production according to the structural framework of “Data – Tools – Platform”, transforming the traditional linear workflow into a collaborative and interactive network system driven by data intelligence (Fig. 2).

<sup>4</sup> SIBAYI 2009.

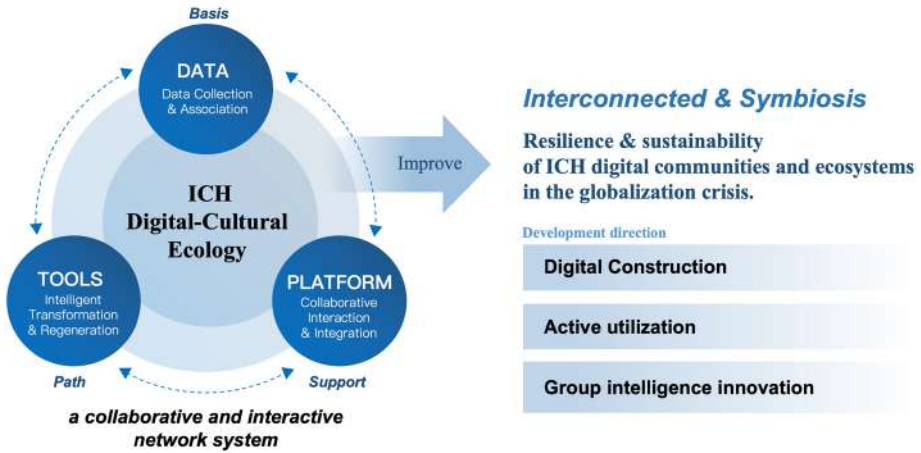


Fig. 2. ICH Digital-Cultural Ecology. Image source: Drawn by the author.

## 1. DATA: Multi-Source Collection and Associated Sharing

Data is not only the foundation of ICH digital cultural ecology, but also the core element of the deep integration of culture and technology<sup>5</sup>. We continue to monitor more than 90 cultural big data platforms around the world, including Europeana, Google Arts and Culture, and pathways for integrating heterogeneous multi-source ICH data. Relying on the National Key Laboratory of Digital Cultural Creative Intelligent Design Technology, we have reached data sharing agreements with China National Museum, China Silk Museum, Hunan Museum and other organizations, and built a database of classic cultural elements and prototypes, which integrates more than 20,000 pieces of cultural data with a data reserve of 1.5PB, and supports categorized storage and intelligent generation of various cultural styles, serving professional users such as designers, museums, inheritors and manufacturers.

Through technologies such as 3D scanning, motion capture, modeling and indexing, knowledge graph, and traceability adaptation, ICH resources are digitally collected, cleaned, optimized, classified, stored and associated. On this basis, we developed a database of ICH elements and prototypes, constructed a multi-source collection and association sharing

<sup>5</sup> YAN *et al.* 2024.

technology system for ICH resources, and formed methods for data fusion and structured linkage across systems for a multi-source heterogeneous ICH big data platform. To date, we have conducted digital collection and processing for various cultural heritage such as ceramics, costume, bronze, paper cuttings, wood carving, bamboo weaving, stone carving, etc., and established a big data resource platform of heritage culture with Chinese style (Fig. 3).



Fig. 3. Chinese Design Style Cultural Heritage Big Data Platform. Image source: Drawn by the author.

## 2. TOOLS: Intelligent Transformation and Creative Regeneration

Tools are not only a critical path for transforming data into creativity, but also a driving force for unleashing the effectiveness of cultural resources<sup>6</sup>. Therefore, we integrate tools such as Artificial Intelligence Generated Content (AIGC), Digital Content Construction (DCC), machine learning, intelligent generation, dynamic capture, and cross channel representation, to study digital cultural creativity methods from the following three aspects:

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<sup>6</sup> LEVAN 2023, 17.

- Style Quantification Method Based on Big Data Analysis.
- Extract the key factors of Chinese style, like modeling features, design elements, era style, and convert them into numbers or glossary information, conduct a large amount of data statistics, and then establish a quantitative description template of Chinese style semantics.
- Visual Feature Modeling and Intelligent Semantic Processing.
- We construct a semantic library according to the visual feature representation model of creative design, and the natural semantics are transformed into the quantitative representation of the corresponding semantic groups to form a quantifiable intelligent semantic model.
- Collaborative Technology and Intelligent Design Tool.

Through the deep and organic integration of intelligent technology and design services, reduce costs and improve design efficiency. Realize design tool development, knowledge acquisition and generation, collaboration and sharing, evaluation and evolution, service architecture, etc. (Fig. 4).

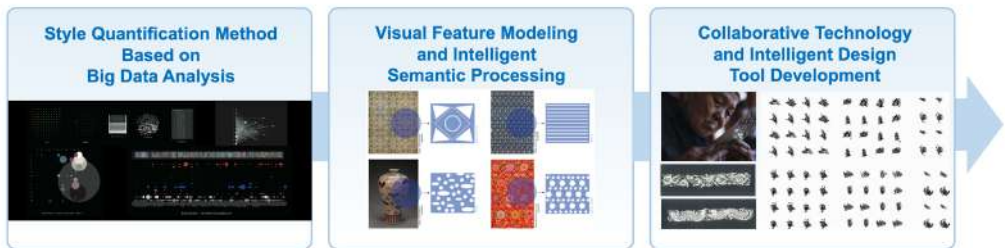


Fig. 4. Intelligent Transformation and Creative Regeneration Methods. Image source: Drawn by the author.

### 3. PLATFORM: Collaborative Interaction and Integration

The platform provides the foundation for the integrated development of cultural data and the substantial economy, as well as the support for the open sharing of cultural data<sup>7</sup>. Based on digital cultural experience, intelligent interaction and service technology, we integrate the intelligent construction of digital cultural scenes, the multi-modal interaction of digital cultural experience, and the cross-media innovation method of digital service platforms,

<sup>7</sup> PESCE *et al.* 2019, 1883-1903.

and construct the visual presentation, integrated application and targeted service delivery mechanism of ICH in complex digital scenarios.

Taking the national ICH project Dong Brocade as an example, we conducted cultural aesthetic research on five aspects of the collected Dong brocade cultural prototypes: patterns, configurations, colors, semantics, and craftsmanship. This effort led to the development of pattern libraries, configuration libraries, inspiration libraries, product libraries, and color libraries for Dong brocade. Leveraging parametric and intelligent AIGC technologies, we established a methodological system for intelligent and innovative design in Dong brocade (Fig. 5).

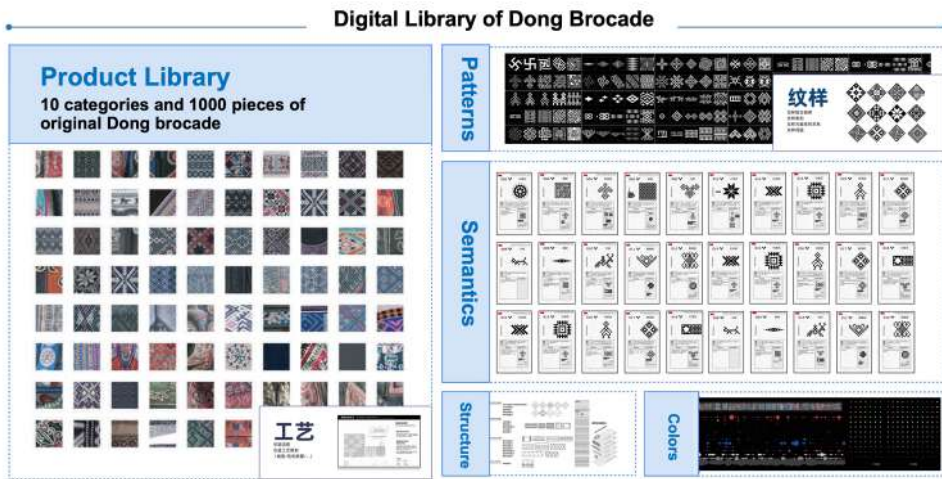


Fig. 5. Dong brocade cultural prototype databases. Image source: Drawn by the author.

In conclusion, based on the research above, we established an innovative ecological framework for ICH that integrates “handcrafted production, industrial production, and digital intelligence.” This framework elucidates the dynamic development process of ICH from multiple dimensions, including technological pathways, ontological connotations, and social value. This work achieves a design-based interpretation of the “new qualitative productivity” of ICH in the context of the new era.

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# THE “RESTORATION ROAD” CULTURE AND PRACTICE OF HERITAGE CONSERVATION AND ENHANCEMENT

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**Keywords:** china center, restoration road, heritage, conservation

## 1. Premises

The history of the relations between the Politecnico of Torino and China has a significant starting point in 2005 with the *Politong Program*, which involved PoliTO, Tongji University (Shanghai), and Politecnico of Milano. Stemming from intergovernmental dialogue between Italy and China, the project was funded by the Italian Ministry of Education, Universities and Research (MUR) until 2013 and subsequently primarily by China. Over the years, more than 1000 students have benefited from the program in Information and Communication Engineering, Mechanical and Production Engineering, and Systemic Design. In 2017 finally, Politecnico of Torino established the China Center<sup>1</sup> with the aim of offering a strategic vision and dedicated management of activities in which China is the leading partner.

The China Center introduced several structural innovative aspects into PoliTO's approach to China and intends to promote and facilitate relations and communications with Chinese institutions; provide support for planning and management of projects and research activities with Chinese partners; strengthen the competitiveness of the Politecnico in China in the field of training, research, and consultancy in the academic, institutional and industrial sectors; increase the familiarity of scholars and professionals with the Chinese university system and the Chinese market.

It should be noted that the China Center is not conceived as a Research or an Innovation center but rather as a facilitator/promoter of the research and training activities conducted by the PoliTO departments in cooperation with Chinese partners. The China

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<sup>1</sup> <https://www.polito.it/en/polito/international-campus/politecnico-around-the-world/china-center> (last consultation 02/01/2025).

Center supports specific research groups such as the China Room<sup>2</sup>, established in 2016, dedicated to urban and architecture studies in China, or the automotive group, recently enriched with a specific headquarters dedicated to Chinese collaborations and supporting various individual researchers or small groups as well.

Since its start in 2018, the China Center has contributed to achieving different results alongside implementing traditional education programs in partnership with top partner HEIs, such as bilateral Student Exchange agreements and Double Degree agreements at all levels.

Among the latter, we can mention the Joint PhD in Architecture with Tsinghua University (2018), the Agreement on scholarships for full-degree and visiting PhD students (2019, China Scholarship Council, CSC), the DD Master of Science in Urban Design with South China University of Technology (SCUT, from 2020)<sup>3</sup>.

## **2. Intersecting perspectives on the future of architectural heritage: best practices in academic cooperation between Italy and China**

It is precisely within the scope of the Dual Master's Degree Program in Urban Design with SCUT (South China University of Technology) in the *Restoration* course that studies have been started that concern the conservation and enhancement of the Ancestral Hall in the Village of Lijiao<sup>4</sup>. The teaching activity involved a group of 30 students who worked on the subject of the exercise starting from a study and analysis of the current context, with a methodological approach attentive to the transformations of urban morphology. The fundamental objective was to identify the remains of the original urban system, undergoing strong transformation and demolition, with the aim of protecting and preserving its identity. This activity was then followed by a careful analysis of the geometric and architectural structure of the studied assets, with an identification of the materials and their state of

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<sup>2</sup> <https://chinaroom.polito.it> (last consultation 02/01/2025).

<sup>3</sup> More details in BONAGLIA, BONINO, FACCHINETTI, FRISOLI, BEGANI, GOTTARDO, GONZO, 2023. Similarly, in the field of Architecture, Politecnico has had the opportunity to develop contacts not only with large public institutions, like universities and their design institutes but also with private firms, which have led to significant design opportunities. These opportunities are not only meant as business opportunities but can help PoliTO understand a rapidly transforming reality. In some cases, these relations have involved other entities in the Turin area, which PoliTO collaborates with, and in particular, some architectural firms involved in international collaboration - especially in China - with PoliTO through an agreement signed in 2019 with the Torino Council of Architects.

<sup>4</sup> The Restoration course, active since the 2020 academic year, is held by Professors Emanuele Morezzi and Francesco Novelli, from Politecnico of Torino. For similar contributions, see also PUGNALONI, CARLOROSI, ISSINI, 2011.

alteration to identify possible restoration interventions. The results of these investigations constitute a wealth of knowledge that is very important for the drafting and testing of new guidelines aimed at the implementation of planned conservation programs for this heritage, respecting its material and immaterial value components.

Also, within the framework of cooperation between Politecnico of Torino and South China University of Technology, on December 6, 2024, the Cantonese Opera Art Museum in Guangzhou hosted the *Sino-Italian Heritage Day*, an event dedicated to promoting the recovery, enhancement, and preservation of architectural and urban heritage in South China’s Greater Bay Area (GBA).

The initiative, organized by the Department of Architecture and Design at Politecnico of Torino and the School of Architecture at the South China University of Technology, with support from the Consulate General of Italy in Guangzhou and Urban Elephant Architects and Politecnico of Torino China Center, reinforced the partnership between the two universities, which began in 2016.

The day highlighted the added value of cultural heritage recovery across architectural, landscape, and industrial contexts, remarking how Italy and China are the two nations with the highest number of UNESCO World Heritage Sites. In this process, preserving heritage and passing it on to future generations means keeping alive the material and intangible values embodied in every artifact through in-depth knowledge and projects that ensure their relevance in contemporary life.

The event of Heritage Day has also been the occasion to introduce presentations by academic experts from Italian and Chinese institutions emphasizing the vital role of cultural education in heritage preservation, showcasing interventions on archaeological sites, and exploring how cultural heritage can drive high-quality urban-rural development<sup>5</sup>.

Moreover, it was presented *La Via del Restauro (Restoration Road)*, a project developed in collaboration with the Conservation and Restoration Center at La Venaria Reale (Italy)<sup>6</sup>. The project’s objectives are aimed at highlighting how the dialogue between historical landscapes and contemporary architecture is a fundamental principle for preserving territorial heritage. Thoughtfully integrated contemporary structures can enrich historic settings with new meanings and narratives.

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<sup>5</sup> Luigi Franciosini, professor of Architectural and Urban Design at Roma Tre University (Italy), and Cao Jing, representing the Guangdong Provincial Institute of Cultural Relics and Archaeology.

<sup>6</sup> The project was presented by Carla Bartolozzi and Francesco Novelli, with a speech entitled *Intersecting perspectives on the future of architectural heritage*. Carla Bartolozzi is the scientific director and creator of the project, together with Michele Bonino (Director of the Department of Architecture and Design) and Sara Abram (General Secretary of the CCR - Center for Conservation and Restoration Venaria Reale).



### 3. Conclusion

The initiatives cited which, of course, do not claim to be an exhaustive account of a broad and articulated international comparison, represent, however, a (virtuous) synthesis of comparison and cooperation, consolidated over the years with agreements and collaborations still active between the Politecnico di Torino and the Chinese partner universities.

The same documentaries briefly illustrated want to encourage and promote, in terms of cooperation, activities aimed at the creation of workshops intended as places of exchange, where work will be done on cultural comparison and the different operational practices, from the restoration project to the conservation interventions on individual assets, to the scheduled maintenance plans.

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<https://youtu.be/mKN1PCkn59k>



# PROTECTING CULTURAL HERITAGE AND FOSTERING DESIGN INNOVATION IN THE CENTRAL PLAINS REGION: THE CRADLE OF CHINESE CIVILIZATION

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**Keywords:** cultural heritage preservation, design innovation, central plains culture, digital heritage experience, youth cultural identity

## 1. Introduction

The Central Plains region, centered on Henan, is rich in various forms of tangible and intangible cultural heritage. These cultural heritages are highly valued by both the government and the public and multiple preservation initiatives have been undertaken. Design plays a crucial role in the protection and innovative inheritance of cultural heritage. This paper will discuss the following aspects: the visual representation of traditional culture, the digitalization and virtual reality experience of cultural heritage, and the revitalization of cultural heritage through exhibitions and shows.

## 2. Visual Representation of Traditional Culture

### 2.1 *Tai Chi as a Symbolic Design Reference*

Tai Chi was developed in the mid-17th century in Chenjiagou, Wen County, Jiaozuo City, Henan Province. Its martial arts philosophy of promoting harmony and utilizing softness to overcome hardness reflects the traditional Chinese values of ecological harmony, natural balance and social equilibrium. The designer employs the movements of Tai Chi as a symbolic design reference library, using visual design methods to graphically convey the fluid movements of Tai Chi, thereby enhancing public understanding and appreciation through visual communication. The creation process also incorporates the concept of “round on the outside and square on the inside, combining hardness and softness”, employing the concept of form transcending shape to visually present the movements.

## 2.2 *Integration of Traditional Patterns into Modern Designs*

Bronze mirrors are a highly representative feminine artifact in ancient China. The designer focuses on young female consumers, integrating traditional patterns from the Central Plains into modern designs of bronze mirrors, to create cultural yet creative products that possess both cultural significance and practicality. For example, the “Zhu Yan” series mirrors combine traditional patterns with modern design elements, making them appealing to young people.

## 3. Digitalization and Virtual Reality Experience of Cultural Heritage

### 3.1 *Immersively reinterpreting “Along the River During Qingming Festival”*

“Along the River During Qingming Festival” is one of China’s top ten most famous paintings handed down from ancient times. This national treasure-level artwork was painted by Zhang Zeduan during the Northern Song Dynasty and is housed in the Palace Museum in Beijing. It vividly portrays the urban landscape and socio-economic conditions in the 12th-century capital city of Northern Song Dynasty China, known as Dongjing (present-day Kaifeng, Henan). “Only Henan: Drama Fantasy City” is an immersive cultural venue that utilizes modern technologies, such as digital technology and virtual reality, to recreate the “Along the River During Qingming Festival,” presenting cultural heritage in a more vivid and intuitive manner. This enhances public cultural engagement and strengthens cultural identity.

## 4. Revitalization of Cultural Heritage through Exhibitions and Shows

### 4.1 *The Longmen Grottoes and “Longmen King Kong”*

The Longmen Grottoes, located in Luoyang City, Henan Province, represent the world’s largest collection of stone carving art. They have been recognized as a UNESCO World Heritage Site and are regarded as the pinnacle of Chinese stone carving artistry. “Longmen King Kong” is a dance performed during the “Qixi Wonderful Tour” event by HNTV in 2021. It features live footage of the Longmen Grottoes, complemented by special effects technology and combines flying dance with ancient street dance. With an exciting drumbeat and classical melodies, the “Longmen King Kong”, alongside the flying dancers, delivers a compelling performance integrating traditional and modern elements within a symbolic open-air setting. This performance brings the cultural heritage of the Longmen Grottoes to life and enhances people’s cultural experiences.

## **5. Conclusion**

The protection and innovative inheritance of cultural heritage in the Central Plains region is a long-term and challenging task. Design plays a crucial role in this effort. China has emphasized the strategic significance of cultural preservation not only its own cultural heritage but also the cultural heritage of all humanity for future generations. With collective effort and determination, we can successfully continue to preserve these invaluable cultural treasures and contribute to strengthening national cultural identity and pride of the Chinese nation. Future research could focus on further exploring the potential of digital technology in cultural heritage preservation and the development of more culturally significant and practical products for young people.



## NANOTECHNOLOGIES AND ADVANCED MATERIALS FOR THE CONSERVATION OF CULTURAL HERITAGE

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**Keywords:** nanomaterials for conservation, hydrogels and microemulsions, soft matter and surfaces, cultural heritage, technology transfer

CSGI (Consorzio Interuniversitario per lo sviluppo dei Sistemi a Grande Interfase - Center for Colloid and Surface Science) is a public research institution established in 1993 and officially recognised by the Italian government in 1994. It operates under the supervision of the Italian Ministry of University and Research and includes several Italian universities and research centres with strong expertise in the fields of soft matter, surface science, nanomaterials, and nanotechnologies.

The main goal of CSGI is the development and study of new supramolecular, colloidal and nanosystems, with the aim of applying these systems to several industrial fields. Its main activities include fundamental and applied research, resulting in publications, patents and registered trademarks. The consortium also trains young researchers through Bachelor's, Master's, PhD programs, and Marie-Curie Fellowships. CSGI supports small and medium enterprises facilitating their access to the activity of national, international, or large-scale infrastructures laboratories. Over the years, CSGI has become an international network of reference for technology transfer, involving Italian, European, and international research bodies and private companies worldwide (ENI, Procter & Gamble, BioMérieux, L'Oreal, pharmaceutical IDI, Shiseido). CSGI's research is supported by a wide range of external funding sources, including European Union Programs, grants from the Italian Government, donations and awards.

Currently, CSGI is composed of 18 Units and 7 Associated laboratories, and gathers about 300 scientists including Full Professors, Associate Professors, and Researchers. One of the main research fields of the Florence unit (the headquarters) is the development and study of innovative materials and methodologies for the preservation of cultural heritage. Following the catastrophic flood of 1966 in Florence, Professor Enzo Ferroni, co-founder of CSGI and the rector of the University of Florence, began collaborating with several conservators and restorers. Together with one of them, Dino Dini, he developed the method

that bears their names, which allowed them to save the most important fresco masterpieces of Italian art from severe degradation and loss.

Over the last 15 years, CSGI has been (and still is) the Coordinator of EU-funded research projects in the field of conservation of cultural heritage: Nano for Art (FP7 program), NanoRestart and Apache (Horizon 2020 program), and the ongoing project Green Art (Horizon Europe program). These projects aim to develop and test new nanomaterials and responsive systems for the conservation and preservation of movable and immovable artworks. The projects' objectives also include the assessment of the applicability of materials, the study of the long-term behaviour of the products and of the treated artworks, and the development of industrial processes for the transfer of technology to market and production of the nanomaterials on medium and large scale.

During these projects several new nanomaterials have been developed:

- Semi-interpenetrated hydrogels: the pHEMA/PVP hydrogel is a semi-interpenetrating network of pHEMA (which provides mechanical strength to the hydrogel) and PVP, which increases the hydrophilicity and the porosity of the system. These gels appear like transparent hydrogel sheets with tunable water-release properties that allow to have a very controlled release of the cleaning fluids confined inside them compared to traditional gels. These formulations are very suitable for the cleaning of very water sensitive artifacts like paper, photos and watercolors.
- PVA-based hydrogels: The PVA-based gels can be prepared via freeze-thawing of PVA solutions. Freeze-thawing (FT) process causes the formation of a porous structure where PVA crystals act as junctions in the final network. These systems appear as sponge-like systems with interconnected porosity, high free water content and a high-water retention. Being physical gels that act like chemical gels, these systems are very adaptable to the clotted and rough surfaces that very often characterize modern and contemporary paintings.
- Microemulsions: These fluids are composed of water (about 80%), surfactant -organized in nanosized assemblies called micelles- and solvents. Since the solvent is confined inside the micelles, the cleaning operation can be longer and milder than cleaning with free solvents. Another important aspect is that the confinement of hydrophobic material inside the oil droplets hinders the redeposition of the removed material onto the painting substrate, as the continuous aqueous medium of the o/w microemulsion (along with the possibility of loading it in sorbents) acts as a "hydrophilic barrier". These formulations significantly reduce toxicity to the operators, works of art and the environment, while maintaining high efficacy.
- Calcium hydroxide nanoparticles: these formulations are composed of calcium hydroxide nanoparticles dispersed in short-chain alcohols such as ethanol and 2-propanol; these systems, also known as nanolimes, are highly compatible with carbonate-based materials,

such as wall paintings and carbonate stone. Due to their compatibility, they represent an alternative to traditional consolidation materials used in restoration practice, for instance synthetic polymer coatings that exhibit poor compatibility with inorganic porous works of art and can produce detrimental effects in the long-term.

These formulations have been tested and validated by important institutions, including the Peggy Guggenheim Collection in Venice and the Tate Modern in London, on masterpieces by artists such as Jackson Pollock, Pablo Picasso, and Roy Lichtenstein. To meet market demands, the Consortium has registered five trademarks and developed a web platform to make its formulations accessible to conservators. In 2023, the Consortium's commitment to environmental responsibility and innovation was recognized by the Solar Impulse Foundation, which awarded CSGI for the eco-compatibility, safety, and sustainability of its solutions. This prestigious acknowledgment highlights the Consortium's efforts to combine cutting-edge scientific advancements with a strong focus on ecological and ethical practices, reinforcing its position as a leader in the field. Currently, the Consortium is working on establishing an innovative start-up to bring these products to the market on a larger scale and create job opportunities for the researchers involved. The project is led by Professor Baglioni, who continues to guide the team with passion and dedication.

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# RESEARCH ON TECHNOLOGY SUPPORTING THE INHERITANCE, PROTECTION AND INNOVATIVE DEVELOPMENT OF BEIJING'S INTANGIBLE CULTURAL HERITAGE AT MUSEUMS AND CULTURAL INSTITUTIONS

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**Keywords:** intangible cultural heritage, digital preservation, cultural and creative industries, virtual and immersive technologies, public participation

## **1. The supporting role of technology in the protection and innovation of the intangible cultural heritage at Museums and Cultural Institutions**

### *1.1 Modern science and technology provide technical support for the recording and storage of ICH at museums and cultural institutions.*

Modern science and technology can provide technical support for Intangible cultural heritage (ICH for short) records that are on the verge of disappearing. Film, television, and new media technologies play a critical role in the urgent preservation of intangible cultural heritage projects that are difficult and on the verge of disappearing in live transmission and can record and survive intangible cultural heritage contents such as skills and usage scenes.

Digital technology provides new technical means for the collection and storage of ICH at museums and cultural institutions. The establishment of cultural heritage databases and websites, and digital processing of archives of ICH projects can effectively protect intangible cultural heritage resources and facilitate people's retrieval and inquiry.

### *1.2 Modern science and technology help the inheritance and dissemination of ICH at museums and cultural institutions.*

Digital technology enhances the transmission of ICH within museums and cultural institutions. Modern science and technology can improve the level of exhibition and operation and maintenance of ICH at museums and cultural institutions and promote the inheritance of ICH through online and other means.

Digital technology promotes the spread of ICH at museums and cultural institutions. Digital media overcomes temporal and spatial limitations, providing widespread access to ICH content.

### *1.3 Modern technology promotes the development of cultural creative products of ICH at museums and cultural institutions.*

Modern technology has spawned a variety of new formats of cultural and creative industries, such as immersive experience, “ICH + live broadcast” and “ICH + tourism”.

Modern science and technology promote the creation of cultural heritage brands. For example, “Go to the New Forbidden City”, and “I Repaired Cultural Relics in the Forbidden City”, used advanced technological means to establish a “Digital Forbidden City” to let the excellent traditional culture sleeping in the museum go out of the “palace gate”.

## **2. Current Status of Technology Supporting the Inheritance, Protection and Innovative Development of Beijing’s ICH at Museums and Cultural Institutions**

### *2.1 Policy Environment*

#### 2.1.1 Relevant National Policies Issued in Recent Years

In 2016, the Ministry of Culture and three other ministries jointly issued the “Opinions on Promoting the Development of Cultural and Creative Products by Cultural and Cultural Relics Entities”, proposing “to develop various cultural and creative products based on the cultural resources of cultural and cultural relics entities”.

In 2021, the Ministry of Culture and Tourism issued the “14<sup>th</sup> Five-Year Plan for the Protection of Intangible Cultural Heritage” and identified “strengthening the construction of intangible cultural heritage archives and databases” as an important task for ICH protection during the 14<sup>th</sup> Five-Year Plan period. Subsequently, the General Office of the CPC Central Committee and the State Council issued the “Opinions on Further Strengthening the Protection of Intangible Cultural Heritage”.

#### 2.1.2 Relevant Policies Issued by Beijing Municipal Government in Recent Years

In 2018, the “Opinions on Implementing the Pilot Work of Promoting the Development of Cultural and Creative Products by Cultural and Cultural Relics Entities in Beijing” was issued, proposing “to deeply explore and activate the cultural resources of the city’s cultural and historical relics entities, and strengthen the protection and utilization of cultural relics and

the inheritance of cultural heritage”. The “Opinions on Promoting Innovative Development of Cultural and Creative Industries” issued the same year proposed “to vigorously promote the development of cultural and creative products by cultural and historical relics entities, and establish platforms for creative product R&D, investment and financing services, and marketing promotion”.

In 2019, the “Regulations on Intangible Cultural Heritage of Beijing Municipality” was released.

In 2020, the “Implementation Plan for the Inheritance and Development Project of Intangible Cultural Heritage in Beijing” was issued.

The “Beijing’s Medium and Long-Term Plan for Promoting the Construction of a National Cultural Center (2019-2035)” proposed to build a “Beijing model” for the protection and inheritance of intangible cultural heritage, carry out digitization work on the capital’s intangible cultural heritage, and construct relevant digital resource libraries.

## 2.2 *New Achievements*

### 2.2.1 Scientific and Technological Innovation Promotes the Protection and Inheritance of ICH Resources at Museums and Cultural Institutions

Beijing has established a three-level system of national, municipal and district-level intangible cultural heritage lists. By the end of 2023, there were 120 national and 314 municipal representative ICH items.

### 2.2.2 Accelerated Digitization of ICH Resources at Museums and Cultural Institutions

The “China ICH Website · China ICH Digital Museum” has been established, supervised by the Ministry of Culture and Tourism, and operated and managed by the China ICH Center on a daily basis.

The “Digital Forbidden City” is a successful example. Through this applet, audiences can access all the information about the Forbidden City in real-time, and the massive digital resources of the Forbidden City can be searched and readily accessible through a unified interface.

### 2.2.3 VR/AR/AI and Other Technologies Open Up New Experiences for Museums and Cultural Institutions

Immersive experience formats are increasingly emerging, such as the Forbidden City VR film “The Forbidden City: The Palace of the Son of Heaven” by the Palace Museum.

In recent years, Beijing has stepped up the construction of the “City of Museums”, encouraging time-honored brands to register museums, telling the stories of these brands, and turning them into higher-quality living museums, allowing people to better experience the charm of Beijing culture.

#### 2.2.4 Modern Technology Promotes the Development of Cultural and Creative Industries for ICH at Museums and Cultural Institutions

The Forbidden City has introduced internet technology, virtual reality technology, artificial intelligence and other digital technologies to develop the Duanmen Digital Museum, which creates an immersive 3D virtual environment for visitors. Utilizing new media and other advanced technologies, it has launched a series of cultural and creative products to bridge the distance between the Forbidden City and audiences and help to shape the Forbidden City into a flagship cultural IP.

The Capital Museum has held nearly 100 courses on city exploration, folk customs interpretation, cultural relics appreciation, and ICH handicraft experiences. Among them, the city exploration course and the ICH handicraft experience course “Rabbit Figurine Gets a New Look” have become a highlight of the Capital Museum’s night economy activities.

#### 2.2.5 “Internet +” Facilitates the Dissemination and Marketing of ICH at Museums and Cultural Institutions

The forms of “Internet + ICH” are becoming more and more flexible and diverse, ranging from website information to Weibo, Weibo updates, and further to short videos, livestreaming by internet celebrities, and various other diversified dissemination methods.

To better promote the inheritance and dissemination of cultural heritage, many museums have established websites and showcased ICH through them. For example, the Prince Gong Mansion Museum actively disseminates ICH culture through online platforms, featuring ICH as the main content on its official website. Its efforts in integrating online and offline interactions are also noteworthy.

The “Chinese Intangible Cultural Heritage Costume Show” hosted by the Prince Gong Mansion Museum has adopted a combination of online and offline performances that attracted tens of millions of viewers and promoted the inheritance and dissemination of ICH culture.

### **3. Reflections and Suggestions on Technology Supporting the Inheritance and Development of Beijing's ICH at Museums and Cultural Institutions**

#### *3.1 Strengthen Layout and Guidance, Promote the Integrated Development of Technology and ICH Resources at Museums and Cultural Institutions*

##### 3.1.1 Strengthen Top-Level Policy Design and Innovate Systems and Mechanisms

Enhance communication and cooperation among government departments, universities, research institutes, and enterprises, improve the intellectual property protection and relevant management systems for ICH at museums and cultural institutions, and promote the development of ICH cultural and creative products.

##### 3.1.2 Take a Proactive Layout and Leverage the Driving Role of Digital Technology Innovation for ICH at Museums and Cultural Institutions

Implement a digitization strategy for museums, cultural institutions and ICH, and promote their inheritance, protection and innovative development through digital technologies and advanced concepts.

Promote the Application and Transformation of Scientific and Technological Achievements in the Field of ICH at Museums and Cultural Institutions

Focusing on key areas and links, apply modern information technologies such as the internet, big data, blockchain, artificial intelligence, and virtual reality to optimize and improve the informatization system for the protection and inheritance of Beijing's ICH at museums and cultural institutions.

Leverage modern technologies to cultivate and develop new digital cultural formats such as interactive entertainment and immersive experiences.

#### *3.2 Accelerate the Construction of the Beijing ICH Website and Database to Promote the Inheritance and Dissemination of ICH*

##### 3.2.1 Accelerate the Construction of the Beijing ICH Website with the Help of the Internet and Big Data Technologies

Draw on the experience of building ICH websites and databases from the national level and other provinces and cities and construct the "Beijing ICH Website · Beijing ICH Digital Museum".

### 3.2.2 Conduct In-Depth Investigations and Sorting of ICH, and Improve the ICH Database

Collect, organize, and classify the original data information of ICH, establish a data relationship system, and analyze the data under the relationship system. By formulating unified technical standards, digitize the original data information in batches to ensure the standardization, and process-orientation of ICH digitization work.

Utilize advanced technologies such as big data, simulation technology, artificial intelligence, and virtual reality to restore and present the original appearance of ICH at museums and cultural institutions as much as possible.

### 3.3 *Leverage the Role of Museums and Cultural Institutions to Promote the Development of Cultural and Creative Industries for ICH*

#### 3.3.1 Cultivate Local Culture and Create Cultural IPs

Focus on incorporating ICH elements into the design of cultural and creative products. Prioritize exploring the history, legends, and stories behind the tangible and intangible cultural assets within the collections, images, architecture, and traditional crafts, and draw on the core values and aesthetic principles of traditional culture and artistic elements. Combine this with market demand to find the optimal integration point between ICH and cultural and creative products and revitalize cultural resources.

Fully leverage the supporting role of digital technology in cultural product development and content creation to effectively enhance the cultural quality of creative products.

#### 3.3.2 Encourage Cross-Border Cooperation Among Museums and Cultural Institutions to Optimize and Strengthen the Cultural and Creative Industry

Increase cross-border cooperation such as “Museums + ICH”, “Internet + ICH”, and “ICH + Tourism” to develop corresponding products and services, and enhance the consumption, learning, and immersive experience functions of venue spaces.

#### 3.3.3 Strengthen the Construction of an Evaluation System for ICH at Museums and Cultural Institutions, and Conduct Crisis Early Warning and Risk Prevention

Adhere to the priority of protection and greatly promote the unity of heritage protection and revitalization.

### 3.4 *Promote Public Participation to Facilitate the Innovation and Dissemination of ICH at Museums and Cultural Institutions*

#### 3.4.1 Advance Digitization to Enhance the Social Sharing of ICH Resources at Museums and Cultural Institutions

Seize the opportunity of Beijing's construction as an international benchmark city for digitization, strengthen the construction of new infrastructure for ICH at museums and cultural institutions, strengthen the utility of digital resources, and explore new models and paths.

Promote the construction of the Beijing ICH Public Service Platform, Beijing ICH Experience Tourism Platform, Beijing ICH Audio-Visual Hall, Beijing ICH Online Learning Platform, Beijing ICH Exhibition Venue Intelligent Guide Platform, Beijing ICH Digital Image Museum, and more. Open online public lectures by ICH masters to allow more people to participate in the protection, inheritance, and innovative development of ICH at museums and cultural institutions.

#### 3.4.2 Build Internet Dissemination Platforms to Promote the Dissemination and Marketing of Cultural and Creative Products Related to ICH at Museums and Cultural Institutions

In line with the development of the internet and the trend of in-depth media integration and taking advantage of the opportunity presented by Beijing's construction as an international consumption center city, strengthen "Museums and Cultural Institutions + Internet", "ICH + Internet", and "ICH + Livestreaming" to innovate and enrich the carriers and channels for the inheritance and dissemination of ICH at museums and cultural institutions.

#### 3.4.3 Expanding Cultural Openness to Enhance the Brand Influence of ICH at Museums and Cultural Institutions

Leveraging the strategic advantages of Beijing's construction of the "Two Areas", deeply explore the cultural significance of Beijing's ICH resources at museums and cultural institutions, promote their digitization and industrialization, and develop presence in the international market for related cultural and creative products.

Utilize platforms such as trade fairs, cultural expos, art festivals, international book fairs, and international film festivals to plan high-level exchange activities, promote global understanding of China and Beijing, and strengthen the cultural branding of Beijing's culture.

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# STUDY ON THE FEASIBILITY OF THE TG METHOD FOR MAXIMUM WATER CONTENT MEASUREMENT OF WATERLOGGED ARCHAEOLOGICAL WOOD

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**Keywords:** waterlogged archaeological wood, maximum water content (MWC), thermogravimetric analysis (TG), micro-sample analysis, non-destructive testing

The maximum water content (MWC) is an important parameter for evaluating the preservation state of waterlogged wood<sup>1, 2</sup>. There are many methods to measure the maximum water content of wood, including the direct and indirect method<sup>3</sup>.

Generally speaking, the standard for determining the moisture of sound wood and archaeological wood is based on the oven method<sup>4, 5</sup>. For sound wood, the sample size is generally 2x2x2 cm<sup>6</sup>. For archaeological wood a minimum sample size of 2g is required<sup>7</sup>. In the process of real cultural relics conservation, samples are very precious, such as bamboo slips and lacquerwares, which are common in China, so it may be impossible to collect enough samples for testing. In some cases, although enough waterlogged archaeological wood is available, the degradation degree of archaeological wood is generally uneven, especially for large wooden objects. Therefore, the average value of the maximum water content is usually obtained, which cannot accurately describe the preservation state of archaeological wood. In addition, for marine archaeological wood, there are significant amounts of inorganic deposits on the surface and inside, which will seriously affect the measurement of maximum water content.

Based on the principle of minimal intervention, the Thermogravimetric analysis (TG) method was studied. There are many different thermal analysis methods. TG is the most

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<sup>1</sup> FLORIAN 1990.

<sup>2</sup> JONES 2010.

<sup>3</sup> CAMUFFO, BERTOLIN 2012.

<sup>4</sup> DIETSCH *et al.* 2015.

<sup>5</sup> JENSEN, GREGORY 2006.

<sup>6</sup> ISO 13061-1 2014.

<sup>7</sup> WW/T0086 2018.

common one, meaning that the change of sample weight with temperature is measured under the condition of programmed temperature control<sup>8</sup>. For archaeological wood, TG is usually used to study the degradation degree<sup>9</sup>. TG analyzer is a very precise instrument, and the sample used is only mg level.

Thus, is it feasible to accurately determine MWC using milligram-scale samples? In this study, both simulated samples and real archaeological wood samples were tested by TG and oven method, and then the data were compared. Among the archaeological samples used, six were from China, and five from Italy.

Firstly, the feasibility of TG method is verified by simulated samples. The results show that when the sample mass exceeds 30mg, the measured values of TG method and oven method are very close, and the difference is less than 5%. The results indicated that TG method can be used to measure the maximum moisture content.

The test conditions of archaeological wood were determined by using wood fragments excavated from shell mound site in Gaoming, Guangdong Province. When the sample mass is more than 30mg, the MWC value obtained by TG is very close to that obtained by oven drying method, and the deviation is less than 5%. The data variability decreases with the increase of sample mass, and the deviation also decreases. Therefore, for real archaeological wood, the mass of samples should also be higher than 30mg to ensure that the MWC value is not only close to the value obtained by oven-drying method but also has good repeatability.

Coefficient of Variation (CV) is defined as the ratio of standard deviation to mean value, which can be used to characterize the dispersion of data. For the simulated samples, the CV of the data obtained by TG is smaller than that obtained by oven method because of the uniform degradation degree and no inorganic deposits. In other words, in terms of methodology, the accuracy of TG is higher than that of oven method. But for the real waterlogged wood, the CV value of the data obtained by TG method is higher than that obtained by oven dry method, which means that the real waterlogged archaeological wood is uneven. Therefore, the MWC value obtained by TG can reflect the real state of waterlogged archaeological wood.

TG was used to test the wood samples of Nanhai I shipwreck at different depths. The MWC value of 2-4 mm depth is higher than both the 4-6 mm and 0-2 mm layers. This contradicts our understanding of archaeological wood: the degradation degree of wood surface should generally be more serious than that of interior. It is speculated that the inorganic deposits on the surface of the sample lead to this result, which is supported by

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<sup>8</sup> WAGNER 2017.

<sup>9</sup> CAVALLARO *et al.* 2011.

the inorganic deposits on the surface of the sample visible to the naked eye and microscopic observation.

Based on the above research, some samples of Nanhai I shipwreck and Italian archaeological sites were tested. Italian samples are provided by CNR-IVALSA. Italian wood samples come from different regions of Italy and have different wood species. For all five samples, the mass is less than 5g, and the mass of ROMA METRO is less than 2g. It is very difficult to measure MWC by oven dry method, so only TG method is used. As can be seen from the table, the MWC value varies with wood types and locations. The coefficient of variation is about 5%, which means that the data dispersion is low, and the degradation degree of each sample is relatively uniform.

To sum up, TG method is basically the same as the oven method. The only difference is that for the TG method, the oven is very small, the balance accuracy is very high, and the sample size is very small. According to the experimental results, the mass of the sample should not be less than 30mg, and the duration of constant temperature is about half an hour. Compared with the oven dry method, the MWC value obtained by TG is smaller, which is due to the high specific surface area of small samples. Compared with the oven method, the thermogravimetric method is faster and requires smaller sample quantities, and it is of great value in the study of precious waterlogged wooden objects.

### **Annotations**

The content of this lecture is the result of a bilateral project conducted by China Academy of Cultural Heritage (CACH) and Italian National Research Council (CNR) (2019-JBKY-06). Related articles were published in the proceedings of the ICOM-CC WOAM 2019 conference and *Studies in Conservation* (2024, 69(7): 621-634).

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## **FORUM 2**

### **Food Production and Processing Systems**



## FOOD PRODUCTION AND PROCESSING SYSTEMS

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**Keywords:** sustainable agriculture, food security, food safety, digitalization in agri-food systems, climate change adaptation, biodiversity conservation

Science, technology and innovation are essential tools to address the great challenges of our time and in the agri-food sector the current challenges to be faced are numerous and complex. Some of the key ones include: i) climate change and environmental sustainability (climate change can affect crop yields, need of strategies to reduce greenhouse gas emissions and to modify agricultural systems to cope with the changing climate); ii) emerging risks (for instance invasions of alien microorganisms, water scarcity); iii) biodiversity loss (decline in the number, genetic variability and variety of species); iv) food security (ensuring nutritious food for everyone); v) growing demand of quality, safe and nutritious food production which at the same time protects the diversity of ecosystems, soil fertility, air and water quality (consumer understanding of food quality, healthiness and environmental impact); vi) circularity of food and agricultural systems (to minimize wastes, maximize resource efficiency, and create a regenerative cycle of production); vii) digitalization of food system (to use information and communication technology such as machine learning, Artificial Intelligence, Blockchain, and Internet of Things in the food industry); ix) health and nutrition (malnutrition remains a problem in many parts of the world).

These challenges intersect in complex ways and require innovative solutions that balance sustainability and productivity.

Several Italian research institutions, including the National Research Council of Italy, are actively involved in a large number of research projects with the aim of innovating the way of doing agriculture in Italy and producing scientific knowledge that allows us to shape future agricultural and rural systems by increasing the competitiveness, production efficiency and sustainability of our agricultural system, promoting adaptation to climate change and increasing the quality of production.

Among the ongoing projects, AGRITECH - National Research Center for Agricultural Technologies (number of partners: 47, Funds: € 320.070.095, Coordinator: University of Naples Federico II), ONFOODS - Research and innovation network on food

and nutrition Sustainability, Safety and Security – Working ON Foods (number of partners: 26, funds: € 114.500.000, coordinator: University of Parma) and BIODIVERSITY - National Biodiversity Future Center (number of partners: 50 Funds: € 320.026.666, coordinator: National Research Council of Italy), falling within the National Recovery and Resilience Plan (PNRR), and funded by the Ministry of University and Research under the Next Generation EU program of the European Union, are noteworthy projects aimed to lay a sustainable development of the Italian economy.

AGRITECH - National Research Center for Agricultural Technologies (<https://agritechcenter.it/>) carries out research and promotes the development of innovative technologies in the agricultural sector to improve the quantity and quality of production, also ensuring sustainable adaptation to climate change through prevention, resistance and resilience to risks (drought, health emergencies, soil impoverishment). AGRITECH combines the best Italian scientific expertise to enhance the quantity and quality food production chain and to make the Italian agrifood industry more competitive and sustainable.

ONFOODS project (<https://www.onfoods.it/>) aims to promote the sustainability of food production and food distribution, to increase the quality of food and diets, to develop intelligent innovative technologies for sustainable food production and consumption, to guarantee food security and food availability at a global level and for specific population targets. OnFOODS is the Italian research and innovation network for sustainable food and nutrition.

NBFC - National BIODIVERSITY Future Center (<https://www.nbfc.it/en>) conducts research and promotes the development of solutions to monitor, preserve and restore functional biodiversity in order to counteract the anthropic impact and the effects of climate change. At the same time, the Center supports research and innovation activities for the enhancement of biodiversity through circular economy and restoration economy processes, capable of protecting environmental resources and ensuring the well-being of the population. The NBFC is the first national research and innovation center dedicated to biodiversity. More than 2,000 researchers working within the center implementing basic, applied and innovative research actions dedicated to Mediterranean biodiversity to generate value for the country.

The session “Food production and processing systems”, thanks to the contribution of Italian and Chinese experts, dealt with some of the previously mentioned themes and challenges in the agri-food sector. I hope that the contents of this session will provide valuable insights and stimulate further research in this field.

## THE CHALLENGES OF AGRIFOOD SECTOR: THE ROLE OF RESEARCH INFRASTRUCTURES

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**Keywords:** Research Infrastructures (RIs), agrifood sustainability, food safety and traceability, digitalization in agrifood systems, one health approach

The agrifood sector represents a strategic pillar for society, but it faces complex challenges related to various aspects such as quality, safety, traceability, circular economy, sustainability, agroecological transition, and digitalization. It is also crucial to consider environmental and social factors related to agriculture & environment, consumers & health. How can we address these challenges in an integrated manner and ensure a more sustainable and resilient food future? Agrifood systems are, in fact, structured according to “multiple levels”. First, it is necessary to apply a supply chain approach – “from farm to table”. Then, it’s important to consider the connections between supply chains, and with other systems, such as the industrial, tourism, or cultural sectors, with impacts on the environment, health, and economy. Furthermore, there are various social levels – involving individuals, families, and social groups – and geographical levels – from local to global scales, including regional ones. This complexity requires an integrated and interdisciplinary vision. The challenge, therefore, is to act with an approach that allows us to address in an integrated way all the interconnections among quality, safety and security, sustainability, resilience, traceability, and transparency, effectively implementing the “One Health” approach, which views human, animal, and environmental health as a single system. It’d be also needed to promote digitalization, towards a model inspired by the concept of “Industry 5.0”, with the transition to more sustainable and digital food systems. In this context, Research Infrastructures (RIs) play a crucial role, thanks to their ability to provide resources and services to address complex scientific problems in various domains, including “Health and Food”, promoting an interdisciplinary and long-term research ecosystem. The key elements are a service-oriented organization, an innovation-driven approach, and long-term sustainability. Within this context, METROFOOD-RI, included in the ESFRI Roadmap for the “Health & Food” domain, provides high-quality metrology services in food and nutrition, comprising an important cross-section of highly interdisciplinary and interconnected fields throughout

the food value chain, including agrifood, sustainable development, food safety, quality, traceability and authenticity, environmental safety and human health<sup>1</sup>.

The infrastructure combines a Physical-RI (P-RI) and an electronic-RI (e-RI) for open data deposition, access and processing. The P-RI coordinates and integrates a network of state-of-the-art facilities including laboratories for the full chemical, physical-chemical and microbiological characterisation of foods and any matrix of interest in relation to the agrifood, plants for Reference Material (RM) development and production, experimental fields/farms for crop production and animal breeding, small-scale plants for food processing and storage, kitchen-labs for food preparation, and “demo” sites for direct stakeholder engagement. The e-RI consists of a service-oriented electronic architecture providing an accessible platform for sharing and integrating data, knowledge and information on metrological tools in accordance with FAIR principles for food analysis and for facilitating the availability and use of agrifood data to the user community. It organizes and complements P-RI results with existing data, providing tools for diverse applications. Further, as part of the European Open Science Cloud (EOSC), METROFOOD-RI actively contributes to building Europe’s data space, emphasizing data interoperability and enabling integration with other networks and infrastructures integration. Coordinated by ENEA-Italy, the METROFOOD-RI involves research institutes in 12 European countries. At the national level, the infrastructure is reflected in METROFOOD-IT, currently supported by a dedicated PNRR project (METROFOOD-IT) for the full implementation of the National Node towards its full operation, with the mission of supporting research and innovation in agrifood systems by providing integrated services for traceability, quality, safety, and authenticity of products, accelerating their digitalization and efficiency. Through Research & Development actions, service provision, technology transfer, training & education, and co-creation, the infrastructure aims to promote transparency, enhance the sustainability and resilience of agrifood systems, reduce vulnerability to fraud and adulteration, improve food quality and safety, and promote and demonstrate food transparency. As a service-oriented organization, METROFOOD provides various types of services with physical, remote, virtual, or hybrid access - also offered free of charge through the launch of dedicated open calls. It encompasses a comprehensive range of services, including research services (spanning the areas of agrifood, metrology tools, health, environment, and sustainability), ICT and data services, advisory services, as well as education and training. Research services place a strong emphasis on food and feed analyses, leveraging advanced metrological tools to ensure reliability in measurement results across the entire agrifood value chain. Moreover, a suite of integrated services is available, which combine the multidisciplinary expertise, resources,

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<sup>1</sup> TSIMIDOU *et al.* 2022; H2020 METROFOOD-PP CONSORTIUM 2022; METROFOOD-EPI 2024.

and facilities to address complex challenges in food systems, spanning key areas such as transparency in the food chain, emerging food risks, innovative processing, new-generation packaging solutions, and circular bioeconomy approaches. Therefore, METROFOOD offers an advanced technological ecosystem that provides integrated solutions and an open data platform to support researchers, policymakers, businesses, and citizens, acting as an interface, on one side, between science & policy through interactions with policymakers, and on the other side, between science & society through the provision of services and direct stakeholder engagement initiatives, including the implementation of Living Labs for co-creation of knowledge and targeted solutions and optimization of the services offered. We can thus state that METROFOOD acts as a booster for the development of knowledge and skills, with concrete impacts, such as enhancing products, promoting healthy and sustainable diets, supporting innovation, competitiveness, and social cohesion, and strengthening consumer trust in the production system<sup>2</sup>. In conclusion, this contributes to achieving the United Nations Sustainable Development Goals and transforming global food systems towards a more resilient, equitable, responsible, and sustainable food future.

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<sup>2</sup> STELZL *et al.* 2023.



# CHINA COARSE CEREAL POWER: THE GREAT POTENTIAL OF BUCKWHEAT FUNCTIONAL FOOD INNOVATION

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**Keywords:** buckwheat, functional food innovation, food production, food processing system, nutritional and medicinal benefits, product development

## 1. Introduction

Buckwheat stands out as a crop of considerable potential, particularly in China, where it is affectionately described as a “small crop, big industry”. As the world’s foremost producer, China boasts abundant buckwheat resources and a robust production base, conferring great economic value and vast prospects for development<sup>1</sup>. Despite these advantages, the buckwheat industry has yet to fully realize its potential due to an underdeveloped quality control infrastructure, inadequate safety assessments, and a significant research gap in the crop’s nutritional and medicinal applications. This paper seeks to comprehensively review the development of buckwheat in China by examining its historical background and significance, health-related functionalities, recent breeding advances, product innovations, and broader industrial development prospects.

## 2. Background and Significance

The cultivation and utilization of buckwheat in China span centuries, intertwining with both food culture and traditional medicine. Extensive scientific analyses have established that buckwheat is rich in bioactive compounds, such as flavonoids, phenolic acids, D-chiral inositol, peptides, and polysaccharides-which provide a diverse range of health benefits<sup>2</sup>. Numerous studies have demonstrated the crop’s capability to regulate blood glucose,

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<sup>1</sup> ZHAO, SHAN 2009, 244.

<sup>2</sup> ZOU *et al.* 2023, 657-673.

improve lipid profiles, support blood pressure control, and enhance immune function, largely due to its strong antioxidant properties<sup>3</sup>. Nevertheless, the current landscape of the buckwheat industry is challenged by reliance on outdated processing methods, limited variety selection, and product homogeneity. Tackling these issues is essential for realizing the full value of buckwheat, moving beyond its traditional uses toward a future as a high-quality functional food and medicinal resource.

### 3. Medicinal Properties

Modern research continues to reveal a broad array of medicinal benefits attributed to buckwheat, particularly Tartary buckwheat<sup>4</sup>. Dietary supplementation with buckwheat has been shown to beneficially modulate the gut microbiome<sup>5</sup> and lower blood pressure<sup>6</sup>, with studies in animal models indicating improved vascular and metabolic function. In addition, continuous consumption of buckwheat has been linked to reductions in body weight and hepatic fat accumulation, as well as improvements in lipid metabolism. Certain proteins within Tartary buckwheat exhibit bile acid-binding properties and inhibit cholesterol-related enzymes, helping maintain healthy lipid levels<sup>7</sup>. Furthermore, both buckwheat bran and its unique D-chiral inositol component exert insulin-like effects, reducing blood sugar and insulin resistance in diabetic models<sup>8</sup>; fermentation-based processing can further enhance these hypoglycemic outcomes<sup>9</sup>. Buckwheat's immunomodulatory benefits are also noteworthy, as compounds such as sprout pectin have strengthened antioxidant activity, improved intestinal barrier function, restored microbiota balance, and attenuated inflammation in experimental settings<sup>10</sup>.

### 4. Advances in Varietal Improvement

Considerable strides have been made in the development and dissemination of new buckwheat varieties. For instance, the release of “MiQiao No. 1” the world's first easily dehulled Tartary buckwheat variety, permits the efficient mechanical processing of “buckwheat pearl rice” and greatly enhances product quality. Breeding efforts have also produced polyploid lines

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<sup>3</sup> ZOU *et al.* 2023, 657-673.

<sup>4</sup> ZHAO, ZOU 2012, 264.

<sup>5</sup> LIU *et al.* 2021, 2457.

<sup>6</sup> NAKAMURA *et al.* 2013, 406-415.

<sup>7</sup> ZHANG *et al.* 2017, 1900-1906.

<sup>8</sup> HE *et al.* 2022.

<sup>9</sup> GUO *et al.* 2025, 1-22.

<sup>10</sup> LI *et al.* 2024.

with higher yields and enriched nutritional content, expanding buckwheat's utility for both sprout and powder production<sup>11</sup>. Cultivation innovations, including sodium bicarbonate treatment to boost flavonoid and D-chiral inositol accumulation<sup>12</sup>, as well as ionized titanium to improve nutrient absorption and yield, have significantly raised the crop's agronomic profile<sup>13</sup>. Mechanization, such as small-scale threshing equipment, has further elevated production efficiency and farmer adoption in core producing regions.

## 5. Product Development and Application

The versatility of buckwheat has fueled the emergence of an increasingly diverse product portfolio. New food products - ranging from rice flour pastries and baked goods to nutrient powders - benefit from advanced processing techniques designed to maximize both nutrition and sensory qualities. The development of specialty buckwheat teas and alcoholic beverages leverages innovative technology to enhance bioactive retention, flavor, and acceptance. For instance, the successful production of Tartary buckwheat rice wine and beer has addressed key technical challenges, resulting in products with high flavonoid content and improved market competitiveness. Beyond traditional food categories, health-oriented products, including flavonoid capsules, high fiber powders, and nutritional tablets, are being introduced to meet consumer demand for functional supplements<sup>14</sup>.

## 6. Industry Prospects

Looking ahead, the continued vitality of the buckwheat industry will depend on integrated industrial strategies. The standardization of cultivation and processing protocols is required to ensure consistent quality and product safety. Expanding the range of buckwheat-based products can better satisfy evolving consumer preferences, while close cooperation among academic institutions, government bodies, enterprises, and farmers will underpin technological and industrial innovation. Notably, buckwheat products have already entered international markets through major retailers, signaling strong potential for further global expansion, increased brand awareness, and greater recognition of the crop's nutritional and health-promoting benefits.

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<sup>11</sup> ZHAO *et al.* 2015, 458.

<sup>12</sup> QIN, *et al.* 2017, 124-130.

<sup>13</sup> ZHAO *et al.* 2015, 458; YUAN *et al.* 2021, 139-143.

<sup>14</sup> REN 2015, 402.

## 7. Conclusion

In summary, buckwheat represents a compelling opportunity to address pressing challenges in global nutrition, health, and sustainable agriculture. Continued research, innovation, and cross-sector collaboration hold the key to unlocking buckwheat's full potential, enabling its emergence as a leading ingredient in the development of functional foods with far-reaching impacts.

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## NEW FRONTIERS OF FOOD PROCESSING AND PRESERVATION SYSTEMS

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**Keywords:** food processing, non-thermal technologies, sustainable food systems, 3D food printing, oleogel

Food systems are highly complex systems; they involve all the activities needed for production, processing, distribution and consumption of products from agriculture, forestry and fisheries, as well as for loss and waste management<sup>1</sup>. Raw materials, using various resources such as water, energy, labor of all employees, infrastructure, scientific and technological knowledge, are transformed into ingredients, intermediate products, food and beverages. Processing and preservation processes are responsible for ensuring food safety, extending shelf life, improving nutritional quality and acceptability, increasing convenience, and facilitating storage and transport. The outcomes of these activities are closely related to human health, environmental sustainability and economic development<sup>2</sup>. Food systems are dynamic systems; nowadays, the main drivers for changes are population growth and urbanization, climate change and environmental factors, changing market and consumer demands, technological innovations, as well as political and geopolitical factors. The new challenges of food systems are aimed at achieving the Sustainable Development Goals of the 2030 Agenda, that includes social goals (2. Zero hunger; 3. Good health and well-being, 12. Responsible consumption and production), environmental goals (6. Clean water and sanitation; 13. Climate action; 14. Life below water; 15. Life on land) and economic goals (1. No poverty; 8. Decent work and economic growth; 17. Partnership for the goals)<sup>3</sup>.

How can food processing and preservation contribute to the transition to more sustainable food systems? Innovative technologies, new ingredients, protein sources and foods, and by-product valorization are among the most explored strategies to meet current challenges.

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<sup>1</sup> VON BRAUN *et al.* 2021, 748-750; MICHEL *et al.* 2024, 153.

<sup>2</sup> VON BRAUN *et al.* 2023.

<sup>3</sup> MICHEL *et al.* 2024, 153.

Non-thermal technologies, also known as mild technologies, can be used for sanitization, preservation and stabilization treatments to preserve nutritional and sensory quality, ensure safety, and extend shelf life.

In the Shealthy<sup>4</sup> project, several combined non-thermal technologies were applied to minimally processed fruits and vegetables and fruit and vegetable-based juices and smoothies. Ultrasound, electrified water, plasma-activated water, high-intensity pulsed light, and blue light were used in the washing phase to achieve a sanitizing effect and, thus, a reduction in the microbial load. Bioactive coatings, active packaging, intelligent packaging were used as preservation technologies for minimally processed fruit and vegetables. Ultrasound and high hydrostatic pressure were used as stabilization technologies of juices and smoothies, in alternative to pasteurization. Furthermore, through enzyme/ultrasonic/pulsed electric field assisted extraction and membrane separation technologies, bioactive components were extracted from processing waste and added to coatings and films. The efficacy of non-thermal technologies was evaluated on different products (fennel, lettuce, spinach, pears, cherry tomatoes, juices, smoothies) and for each of them, the combination of technologies was defined, optimized and validated first on a laboratory scale and then implemented on a pilot scale. The results obtained for minimally processed fennel and cherry tomatoes, and for smoothies are briefly presented.

For minimally processed fennel, the aim was to guarantee safety, preserve quality and prolong the shelf life. The technologies implemented were plasma-activated water washing and packaging with active films (polypropylene films added with antioxidant compounds extracted from orange peels). The technologies were effective from a microbiological (yeasts, moulds) and nutritional (total polyphenols vitamin C and antioxidant capacity) point of view. The effect on colour and shelf life were not significant.

For minimally processed cherry tomatoes, the aim was to reduce the microbial load and slow down the senescence phenomena (respiration rate). Plasma-activated or electrified water was used for the washing phase, and the combination of active coating (sodium caseinate, guar gum, beeswax, propyl gallate) and active packaging (polypropylene films with added antioxidant compounds extracted from orange peels) was used as preservation technology. The technologies were effective both from a microbiological point of view (yeast moulds, total bacterial load) and in terms of respiration rate (slowing down the decay of nutritional quality and increase in acidity). Shelf life was increased by 20%.

The production of smoothies involves a double pasteurization step, first for purees and then for puree mixtures. To preserve nutritional and sensory quality, apple and

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<sup>4</sup> SHEALTHY: Non-Thermal physical technologies to preserve Healthiness of fresh and minimally processed fruit and vegetables, granted by EU within the Horizon2020 Program.

strawberry smoothies were stabilized with a high hydrostatic pressure treatment (HPP). The smoothies treated with HPP were microbiologically stable. No change of color and antioxidant capacity was monitored after HPP stabilization. The shelf life increased by 50% (10 months at 4°C).

In the M3Diting<sup>5</sup> project 3D food printing is used to create personalized, nutrient-optimized, and sensory-appealing foods for patients with phenylketonuria (PKU), offering a new horizon in dietary management. Phenylketonuria is a genetic disorder characterized by an inability to metabolize the amino-acid phenylalanine due to a deficiency of the enzyme phenylalanine hydroxylase. The primary management strategy for PKU involves a strict diet, low in high-protein foods and may include specific formulated medical foods and protein substitutes that are phenylalanine-free or low in phenylalanine<sup>6</sup>. The inadequate sensory quality of protein substitutes for PKU negatively affects patients' adherence to the diet, representing a key challenge for research. We are developing food inks based on glycomacropeptide, cocoa butter, tagatose, pineapple powder, and vitamins (vitamin B6, folic acid, vitamin B12); they should allow to prepare 3D printing food, such as protein snacks, customized to the nutritional requirements of patients of different ages.

Our research is also focused on reducing or replacing ingredients such as salt, sugar and saturated fats, with the aim of improving food nutritional quality. While it is well known that excessive intake of salt, sugar and saturated fatty acids have negative health consequences, these ingredients have positive technological properties concerning processability, texture, palatability, and flavor of many products (such as spreads, bakery products, ice cream). Developing alternative ingredients to saturated fats represents a very challenging goal. An alternative is represented by structured vegetable oils, rich in unsaturated fatty acids, through oleogelation. Oleogelation involves the use of an oil and an oleogelator, such as beeswax or carnauba wax. The oleogelator is added to the previously heated oil, the mixture is stirred and cooled to form the gel. Oleogel can be described as a complex system where the vegetal oil is entrapped within a three-dimensional crystalline lattice formed by the oleogelator. Oleogel physical and technological properties can be appropriately designed; they are affected by oil type, type and amount of oleogel, and cooling rate<sup>7</sup>.

Hazelnut and cocoa cream have been developed replacing the cocoa butter with pumpkin seed oil and carnauba wax-based oleogel, and the sugar with Lucuma powder, a natural food sweetener with a high nutritional value. Firstly, the ability of the oleogel

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<sup>5</sup> M3DITING; Development of Medical foods with improved sensory properties and personalized nutritional content for patients with phenylketonuria through extrusion-based 3Dprinting, funded by EU Next Generation EU Italian Ministry of University and Research (PRIN-2022).

<sup>6</sup> RUSSO *et al.* 2024.

<sup>7</sup> BORRIELLO *et al.* 2021, 152; BORRIELLO *et al.* 2022<sup>a</sup>, 375.

chosen to mimic cocoa butter's behavior during refining was verified. The effect of the new ingredients on the structure and physical properties, such as viscosity, oil-holding capacity, water activity and physical stability, of the spreadable creams have been investigated. The addition of both oleogel and Lucuma powder could allow the production of novel spreadable creams with improved health properties due to essential fatty acids and bioactive compounds<sup>8</sup>.

Transformation and preservation processes have a crucial impact on adding value to agriculture, forestry and fisheries products by transforming them into safe, palatable, nutrient dense, more sustainable foods. The study of consumer acceptance of sustainable foods has a significant role.

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<sup>8</sup> BORRIELLO *et al.* 2022<sup>b</sup>, 11.

## PRACTICE OF ESTABLISHING A FAIR, HEALTHY, AND ENVIRONMENTALLY FRIENDLY FOOD SYSTEM IN HENAN, CHINA

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**Keywords:** sustainable agriculture, organic farming innovation, urban food systems, agricultural waste recycling, China Europe cooperation in agriculture

Under the framework of China-Italian cooperation, the innovation and practice of organic sustainable agriculture are gradually demonstrating their unique value and significance. In response to the increasing global urban population's demand for high-quality agricultural products, particularly in the context of Zhengzhou's 13 million residents, we are constructing an urban sustainable agricultural food system from multiple perspectives. This includes researching and promoting sustainable agricultural production methods, accelerating seed research and innovation, improving the ecological environment of farms, and enhancing biodiversity on farms. Additionally, we aim to establish effective interactions between urban communities and farms, thereby enabling more farmers and citizens to benefit from these initiatives.

Firstly, researching and promoting advanced planting technologies is one of the essential pathways for constructing a sustainable food system. By studying the water and fertilizer demands of specific vegetables at different growth stages and the feedback mechanisms of microclimate environments, and by understanding the changes in the physicochemical and biological properties of soil under organic cultivation conditions, along with the responsiveness of crops in terms of growth, yield, and quality, we have developed integrated water and nutrient management models tailored to vegetable crops. These models optimize high-yield and high-quality parameters for water and nutrient supply through precise management, effectively delivering every drop of water to the root zone of the plants. This approach achieves a significant increase in the recycling of water resources, enhancing water utilization efficiency by as much as 25% to 70%, while simultaneously improving vegetable yields and quality.

Particularly under protected cultivation conditions (such as greenhouses and net houses), we have studied the microclimate characteristics and the responsive mechanisms of crops. We elucidate that plants can enhance transpiration and photosynthetic rates by

adjusting their canopy conductance in low-light conditions, thereby providing theoretical support and technical assurance for promoting regional sustainable development, exemplifying a typical cooperation case in China-Italian sustainable agriculture.

Moreover, the recycling of waste is an effective method to enhance agricultural sustainability. On the farm, waste materials such as branches and leaves can be transformed into high-quality organic fertilizers through composting techniques, providing ample nutrition for crop growth. This circular agricultural model not only reduces the environmental pollution caused by agricultural waste but also promotes sustainability.

By leveraging the Organic Seed Innovation Center, we introduce and breed disease-resistant and stress-resistant vegetable varieties suitable for organic cultivation. We screen and demonstrate varieties that are appropriate for local organic farming, achieving stable and high yields without the use of chemical fertilizers, synthetic pesticides, herbicides, or plant hormones.

Secondly, the positioning of urban agriculture and the interaction between agricultural practices and urban communities are crucial approaches for establishing a sustainable agricultural food system. Urban agriculture emphasizes not only the production function of agriculture but also its landscape value and the interaction with urban consumers. By creating aesthetically pleasing and educational agricultural landscapes, we can attract more citizens to visit farms for fruit and vegetable picking on weekends or holidays, thereby involving them in the agricultural planting process and enhancing public awareness of sustainable agriculture and food systems.

Establishing an emotional connection between farms and urban consumers is a key strategy for promoting sustainable agriculture. By developing DIY gardens for citizens, individuals can actively participate in agricultural planting and management. This hands-on experience not only allows citizens to enjoy the pleasure of growing their own food but also produces fresh agricultural products. Furthermore, it fosters interaction and cooperation within the community, creating a positive atmosphere for agricultural participation.

Finally, within the framework of China-European cooperation, we can draw on each other's successful experiences to establish more efficient sustainable agricultural production models. For instance, by introducing advanced agricultural technologies, sharing exemplary management practices, and initiating various forms of urban agriculture collaboration projects, we can promote the deep integration of urban and agricultural systems. This collaboration not only enhances agricultural productivity but also strengthens the agricultural consciousness within urban communities, thereby advancing the development of sustainable agriculture and agricultural food systems.

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# ADVANCED PLANT PHENOTYPING PLATFORMS FOR ENHANCING AGRICULTURAL PRODUCTIVITY UNDER CLIMATE CHANGE

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**Keywords:** plant phenotyping, climate change resilience, precision agriculture, artificial intelligence in agriculture, water scarcity management

## 1. Introduction

Global food security is increasingly jeopardized by desertification and climate change IPCC (2021). The Mediterranean basin, in particular, faces acute threats due to its climatic conditions, which exacerbate water scarcity and agricultural stress. The projected global population increase to 10-12 billion by 2050 amplifies the urgency of this challenge, as agricultural land remains static while resources, especially water, become scarcer.

Agriculture in the Mediterranean demands innovative strategies to enhance crop resilience to drought, salinity, and thermal stress. Plant phenotyping platforms, designed to analyze plant traits quantitatively, provide a scientific basis for improving crop resistance to such adverse conditions. This paper explores the role of phenotyping technologies in addressing these issues and promoting sustainable agriculture.

## 2. The Challenge of Climate Change and Water Scarcity

Water scarcity poses a significant global threat, affecting nearly all nations. Countries such as China, the United States, India, and Brazil, which collectively account for 50% of global food production, face water risks exceeding 50%. Mediterranean countries, including Italy, face 30-40% risk levels. Coupled with climate-induced extremes, these conditions demand technological advancements in crop production systems.

## 3. Plant Phenotyping Technologies: Principles and Applications

Plant phenotyping, as a field of research, has seen considerable growth in response to pressing global challenges such as climate change, population growth, and the reduction of arable

land<sup>1</sup>. It involves the quantitative analysis of plant traits to unravel the genetic, environmental, and management factors that influence productivity, resilience, and responses to stress. These technologies serve as a critical bridge connecting the genotype-environment-management nexus, facilitating the selection of genotypes optimized for specific environmental conditions<sup>2</sup>.

Despite these advancements, the field faces several limitations that span various scales. Automating the acquisition of extensive morphological data at high temporal resolutions, processing and analysing large datasets of morphological and genetic information and performing detailed physiological analyses remain significant challenges. The primary focus of plant phenotyping is to develop crop genotypes that exhibit enhanced productivity and resilience to climatic stresses. Key determinants of crop productivity and resilience include photosynthetic efficiency, the capacity to mitigate photo-oxidative damage, and the effective uptake and utilization of water.

Traditional approaches to measuring these parameters are often time-intensive and require highly skilled personnel, making direct assessments challenging. However, modern phenotyping techniques have introduced innovative methods to infer or estimate these traits rapidly and indirectly. These approaches are applicable across a range of settings, from controlled environments like greenhouses and growth chambers to field-based studies, offering valuable insights into plant responses to abiotic and biotic stresses.

By combining traditional ecophysiological quantification with rapid screening technologies, plant phenotyping is poised to revolutionize our understanding of plant traits and improve our capacity to address global food security and agricultural sustainability in the face of escalating environmental challenges<sup>3</sup>.

Phenotyping operates across molecular, cellular, organismal, and ecosystem levels:

**Molecular and Cellular Phenotyping:** Techniques such as proteomics and metabolomics analyse metabolic pathways affecting growth and stress tolerance.

**Whole-Plant and Ecosystem Phenotyping:** Platforms integrate environmental and management factors, characterizing plants under diverse field conditions.

#### **4. Controlled Environment Platforms**

Controlled environment platforms, including greenhouses and growth chambers, provide high-throughput phenotyping capabilities. For instance, systems with conveyor belts, imaging chambers (NIR, RGB, fluorescence), and automated irrigation stations enable detailed monitoring of plant responses to stress.

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<sup>1</sup> PIERUSCHKA, SCHURR 2019.

<sup>2</sup> COSTA *et al.* 2019.

<sup>3</sup> HAWORTH *et al.* 2023.

These platforms are instrumental in studying metabolic and physiological processes under controlled conditions. Data collected supports genetic improvement programs by identifying traits linked to productivity and resilience.

## 5. Field-Based Phenotyping

Field phenotyping platforms, including drones and ground-based sensors, provide a comprehensive view of plant responses in natural environments. Equipped with hyperspectral, multispectral, LiDAR, and thermal sensors, drones analyse crop health, canopy structure, and physiological processes. Ground sensors measure photosynthesis, transpiration, and fluorescence, validating remote sensing data<sup>4</sup>.

Combining drone-based and ground-level measurements offers an integrated understanding of genotype-environment interactions. Platforms like FenoRover and gantry systems expand these capabilities, facilitating multi-scale experiments across diverse environmental conditions<sup>5</sup>.

## 6. Data Integration and Challenges and Role of Artificial Intelligence

### 6.1 *Big Data Management*

Phenotyping generates vast datasets requiring advanced analytics. Challenges include integrating multivariate datasets from diverse platforms and ensuring compliance with FAIR data principles (Findable, Accessible, Interoperable, Reusable).

### 6.2 *Role of Artificial Intelligence*

Machine learning and deep learning algorithms have revolutionized the identification of novel indices and parameters associated with productivity and stress tolerance in plants. Machine learning, a domain within Artificial Intelligence, is designed to solve learning problems by leveraging previously collected datasets. During the training phase, a predictive model is iteratively optimized using a portion of the dataset, while the remainder is reserved for testing the model's performance. This process ensures robust evaluation and generalizability. In the realm of plant phenotyping, machine learning has emerged as a powerful tool for analysing physiological indicators and quantifying their values. It enables the generation of data-driven

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<sup>4</sup> HAWORTH *et al.* 2023.

<sup>5</sup> HAWORTH *et al.* 2023.

insights into plant status, offering a high-throughput alternative to traditional, labour-intensive methods like expert observations and complex ground-truthing measurements.

Deep learning, an advanced subset of machine learning, takes this capability a step further by addressing the challenge of generalizability across diverse contexts. Unlike conventional approaches such as Partial Least Squares Regression, deep learning models employ multiple interconnected layers that process and refine data hierarchically. Each layer builds upon the output of the previous one, enabling the learning of increasingly abstract and generalized features<sup>6</sup>. This layered architecture allows deep learning to excel in extracting meaningful patterns from large datasets, making it particularly well-suited for high-throughput phenotyping applications.

The insights gained through these advanced algorithms are invaluable for genetic improvement, testing new agricultural products in the field, and producing metabolites with applications in nutraceuticals, cosmeceuticals, and pharmaceuticals. By integrating machine learning and deep learning approaches, researchers can better understand plant responses to environmental conditions, paving the way for enhanced agricultural productivity and resilience.

## 7. Future Perspectives and Applications

Plant phenotyping is pivotal in optimizing resource use and improving agricultural resilience. By integrating genotypic, environmental, and management factors, these technologies support precision agriculture and sustainable productivity<sup>7</sup>. The Mediterranean region, with its diverse terroir, offers unique opportunities for producing high-value bioactive compounds, fostering innovation in functional food and pharmaceutical development.

## 8. Conclusion

Advanced plant phenotyping platforms are indispensable in addressing the challenges of climate change and water scarcity. By enabling the selection of resilient and productive crop varieties, these technologies ensure sustainable agricultural practices and contribute to global food security. Continued investment in phenotyping research, particularly when combined with artificial intelligence, will drive innovation and enhance the resilience of agricultural systems worldwide.

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<sup>6</sup> LECUN, BENGIO, HINTON 2015, 436-444.

<sup>7</sup> HAWORTH *et al.* 2023; VELAZQUEZ-CHAVEZ *et al.* 2024.

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# ANTIBACTERIAL MECHANISM OF ATMOSPHERIC COLD PLASMA AGAINST PSEUDOMONAS FLUORESCENS AND PSEUDOMONAS PUTIDA AND ITS PRESERVATION APPLICATION ON IN-PACKAGED RED SHRIMP PASTE

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**Keywords:** cold plasma, shrimp paste, *pseudomonas* bacteria, antibacterial mechanism, preservation

## 1. Introduction

Red shrimp (*Solenocera crassicornis*), a dominant species in the East China Sea, is valued for its texture and nutrition<sup>1</sup>. With rising demand for high-quality seafood, shrimp paste – produced via the gelation of myofibrillar proteins – has become a key processed product<sup>2</sup>. Unlike traditional surimi, shrimp paste is often frozen raw, resulting in high microbial loads and enzyme activity<sup>3</sup>. Cold chain logistics cannot fully prevent spoilage by psychrophilic bacteria such as *Pseudomonas*, which degrade proteins and generate off-odors<sup>4</sup>. Yet, most current research focuses on texture and flavor, with limited studies on microbial safety during storage.

Atmospheric cold plasma (ACP) is a non-thermal preservation technology that generates reactive oxygen and nitrogen species (ROS/RNS) capable of inactivating bacteria via oxidative damage to membranes and DNA<sup>5</sup>. ACP has been shown to reduce *Pseudomonas* spp. and extend shelf life in aquatic products, but its mechanism against *P. putida* in shrimp paste remains unclear<sup>6</sup>.

This study investigates the antibacterial mechanism of ACP against *P. putida* and its preservation effect on packaged shrimp paste. We hypothesize that ACP-induced RS

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<sup>1</sup> HU *et al.* 2023, 390.

<sup>2</sup> MAN *et al.* 2024, 445.

<sup>3</sup> HUANG *et al.* 2022, 387.

<sup>4</sup> LI *et al.* 2020, 91.

<sup>5</sup> RATHOD *et al.* 2021, 4407-4425.

<sup>6</sup> WANG *et al.* 2024, 443.

inhibits *Pseudomonas* growth by disrupting membranes, enzymes, and DNA. *P. fluorescens* was included as a reference strain. Additionally, molecular docking was used to explore RS – target interactions, offering mechanistic insights and supporting ACP’s application in seafood preservation.

## 2. Materials and methods

### 2.1 ACP Treatment

ACP was applied using a DBD device (BK130/36, Phenix, USA) at 35 kV for 0-3 min (ACP-0 to ACP-3). Ten mL of bacterial suspension was treated in polypropylene bags between aluminum electrodes. RS generation pathways are shown in Figure 1A.

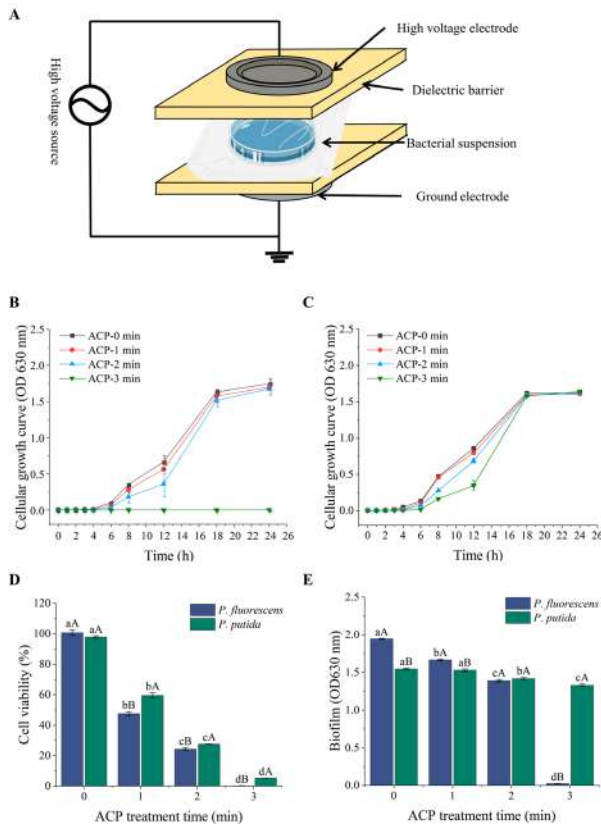


Fig. 1. Scheme diagram of ACP generation using a DBD device (A), changes in the growth curve of *P. fluorescens* (B), the growth curve of *P. putida* (C), cell viability (D), and biofilm during ACP treatment (E).

## 2.2 Physicochemical Properties and Intracellular ROS

Post-treatment, pH (PHS-3C), ozone (GZX-03), NO<sub>x</sub>, and H<sub>2</sub>O<sub>2</sub> were measured using respective kits. Intracellular ROS was quantified using 10 μM DCFH-DA probe and fluorescence measured (Hitachi F-7000, Ex/Em: 488/525 nm). Microscopic imaging followed.

## 2.3 *In vitro* antimicrobial assay

- Growth Curve: Treated/untreated bacteria were inoculated in 96-well plate and incubated at 25 °C. OD<sub>630</sub> was recorded over 24 h.
- Viability (CCK-8): Bacteria with CCK-8 in TSB were incubated at 37 °C for 4 h; OD<sub>450</sub> measured.
- Biofilm Formation: Cells cultured in TSB (25 °C, 24 h), stained with crystal violet, and OD<sub>630</sub> recorded.

## 2.4 Antibacterial mechanism

- Molecular Docking: Binding of H<sub>2</sub>O<sub>2</sub> and HNO<sub>2</sub> to MDH (PDB: 1EMD) and dsDNA (PDB: 6FIX) was modeled via AutoDock Vina.
- SEM: ACP-treated cells were fixed, dehydrated, dried, gold-sputtered, and imaged (Apreo, Thermo, USA).
- Membrane Integrity: After ACP, leakage of nucleic acids (260 nm) and proteins (280 nm) was quantified.
- MDH Activity: Measured using a commercial NAD-MDH kit.
- dsDNA Damage: After lysozyme lysis and SYBR Green I staining, fluorescence was measured (Ex/Em: 485/525 nm).

## 2.5 Shrimp paste preservation

- Preparation: Shrimp meat was minced, filtered, salted, blended with starch and oil, and stored in sterile dishes at 4 °C.
- Inoculation & Treatment: Shrimp paste was sterilized, immersed in bacterial suspension (8 log CFU/mL), dried, bagged, and treated with ACP (0 or 3 min). Samples were named PE, ACP-PE, PP, and ACP-PP. Ozone was monitored every 5 min; samples stored at 4 °C for periodic testing.
- Microbial Analysis: TVC and *Pseudomonas* counts were determined on PCA and CFC agar, respectively.
- TVB-N Content: Determined by Kjeldahl after extraction and MgO treatment.

## 2.6 Statistical analysis

PLS-DA and correlation analysis were performed via MetaboAnalyst 5.0. ANOVA and Duncan's test were conducted using SPSS 22.0. Significance was set at  $p < 0.05$ .

## 3. Results and discussion

### 3.1 Effect of ACP on Physicochemical Properties and Intracellular ROS

ACP treatment led to air ionization and the formation of plasma-activated water, producing reactive species (RS) such as  $O_3$ ,  $H_2O_2$ , and  $NO_x$ .  $O_3$  concentration rapidly rose to  $\sim 786$   $mg/m^3$  within 3 min, with no significant strain difference (Table 1).  $H_2O_2$  levels increased with exposure time, reaching  $\sim 300$   $\mu mol/L$ . Intracellular ROS peaked at 1 min but declined thereafter, likely due to membrane damage and probe leakage.  $NO_x$  levels also increased and contributed to pH drop ( $-7.1$  to  $-6.3$ ), enhancing the toxicity of nitrite in acidic conditions. These findings confirm RS accumulation and their interaction with *Pseudomonas* in acidic environments, laying a foundation for further mechanistic analysis.

Sample	Treatment time	$O_3$ concentration / ( $mg / m^3$ )	$H_2O_2$ concentration / ( $\mu mol / L$ )	Intracellular ROS / (AFU)	Total nitric oxide / ( $\mu mol / L$ )	pH value
<i>P. fluorescens</i>	ACP-0 min	0±0 dA	0.00 dA	377.3±32.4 cA	0.00 dA	7.110±0.04 aA
	ACP-1 min	262±11 cA	185.50±11.68 cA	2061.7±27.6 aA	178.75±14.88 cA	6.78±0.05 bA
	ACP-2 min	493±26 bA	222.60±15.46 bA	2040.0±21.0 aA	281.21±12.86 bA	6.55±0.07 cA
	ACP-3 min	786±23 aA	313.66±32.53 aA	744.3±35.0 bB	310.64±10.08 aA	6.30±0.10 dA
<i>P. putida</i>	ACP-0 min	0±0 dA	0.00 dA	374.8±22.3 cA	0.00 dA	7.17±0.05 aA
	ACP-1 min	267±8 cA	175.38±15.46 cA	1809.0±20.7 aB	175.4±16.78 cA	6.80±0.07 bA
	ACP-2 min	491±24 bA	215.85±25.46 bA	1767.7±40.2 aB	286.8±10.14 bA	6.52±0.07 cA
	ACP-3 min	777±26 aA	300.17±26.77 aA	1492.3±40.7 bA	311.76±6.83 cA	6.32±0.08 dA

Table 1 Changes in  $O_3$ ,  $H_2O_2$ , intracellular ROS, total nitric oxide concentration, and pH value. Data were represented by mean  $\pm$  standard deviation ( $n = 3$ ). Different lowercase letters within the same strains indicated significant differences ( $p < 0.05$ ). Different uppercase letters within the same ACP treatment time indicated significant differences ( $p < 0.05$ ). ACP meant atmospheric cold plasma. AFU meant arbitrary fluorescence units.

### 3.2 Effect of ACP treatment on the inactivation of *P. fluorescens* and *P. putida*

ACP significantly inhibited bacterial growth (Fig. 1B-C), delaying the lag and log phases. Viability assays (Fig. 1D) showed time-dependent reductions, with *P. fluorescens* more susceptible than *P. putida*. Biofilm formation was also suppressed (Fig. 1E), particularly in *P. fluorescens*, where a 98.7% reduction was observed after 3 min. The greater resistance of *P. putida* was attributed to its cold adaptation and efflux systems.

### 3.3 Antibacterial Mechanism of ACP

ACP-induced RS caused intracellular oxidative stress, leading to membrane damage and content leakage. Fluorescence microscopy (Fig. 2A) and SEM (Fig. 2B) confirmed disrupted membranes and probe loss. Nucleic acid and protein leakage increased with treatment time (Fig. 3A-B). MDH activity and dsDNA fluorescence declined significantly (Fig. 3C-D), indicating enzyme and genetic damage. Molecular docking (Fig. 4) revealed H<sub>2</sub>O<sub>2</sub> and HNO<sub>2</sub> formed hydrogen bonds with key residues in MDH and DNA base pairs, disrupting their function and structure. Thus, ACP-induced RS act synergistically to impair cellular components and promote bacterial inactivation (Fig. 5).

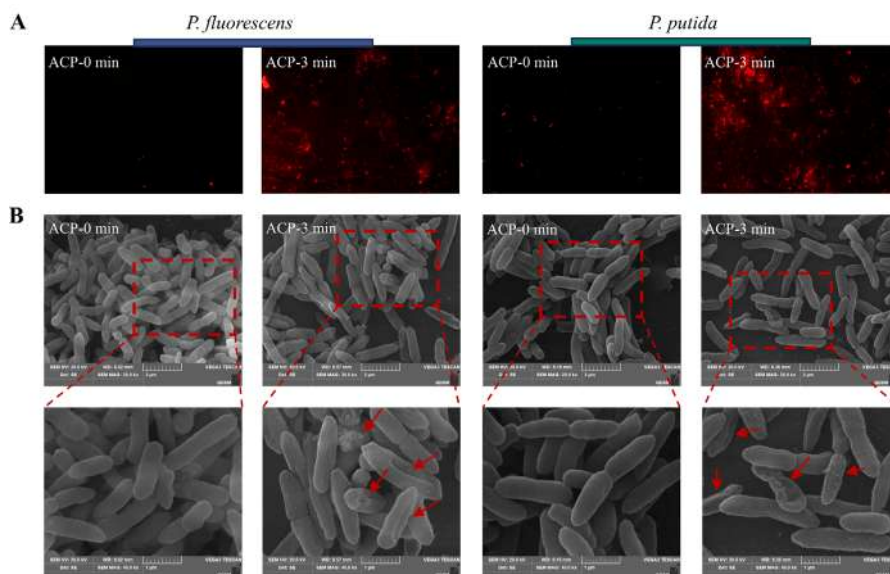


Fig. 2. ROS fluorescence microscope diagram (A) and SEM images (B) of *P. fluorescens*, treated with ACP - 0 min and 3 min, and *P. putida* treated with ACP - 0 min and 3 min. ROS meant reactive oxygen species; ACP meant atmospheric cold plasma.

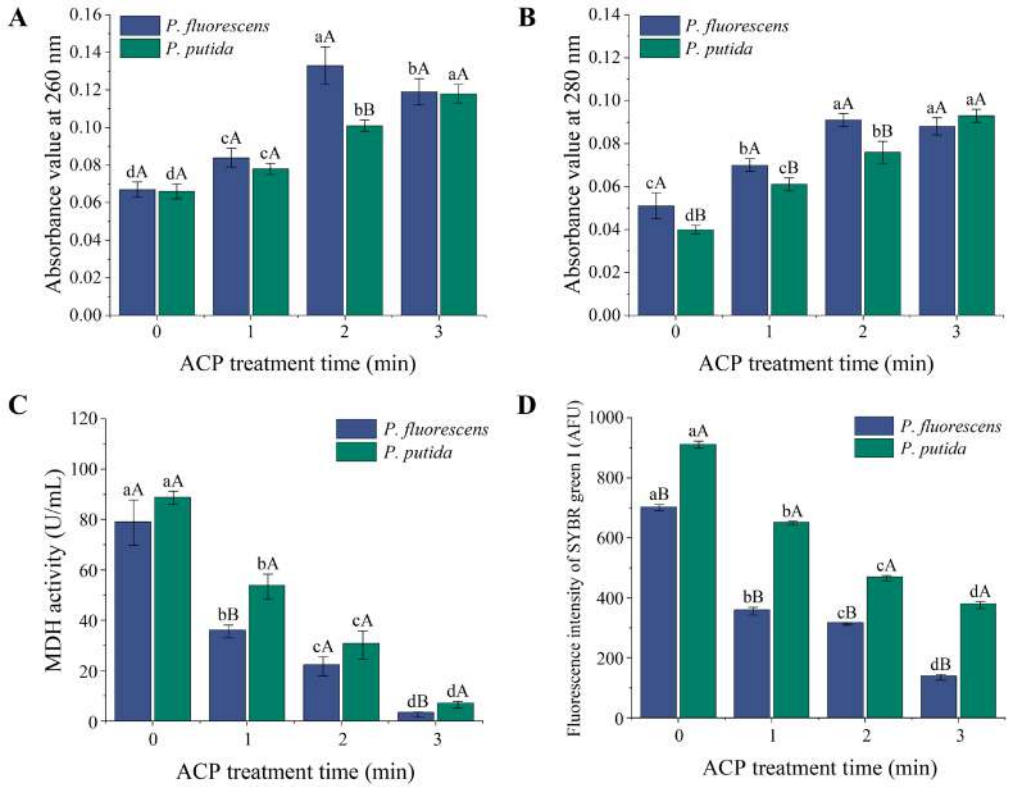


Fig. 3. Changes in the nucleic acid leakage (A), protein leakage (B), MDH activity (C), and dsDNA fluorescence intensity (D) of *P. fluorescens* and *P. putida* during ACP treatment.

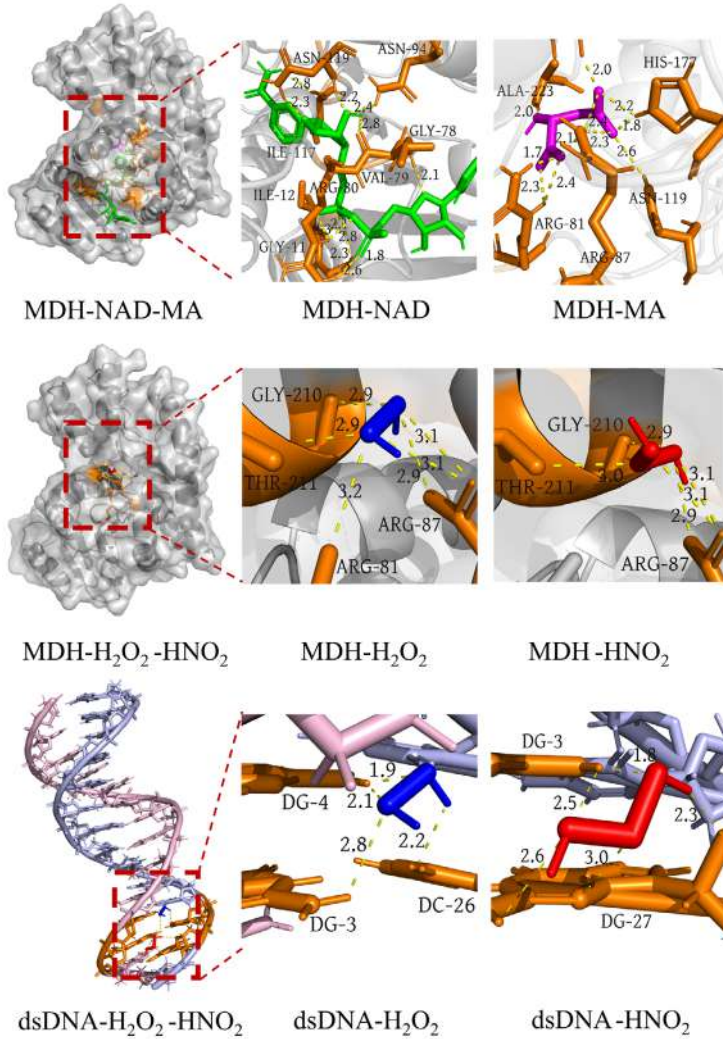


Fig. 4. Ligand molecular docking simulation of *P. fluorescens* and *P. putida* during ACP treatment.

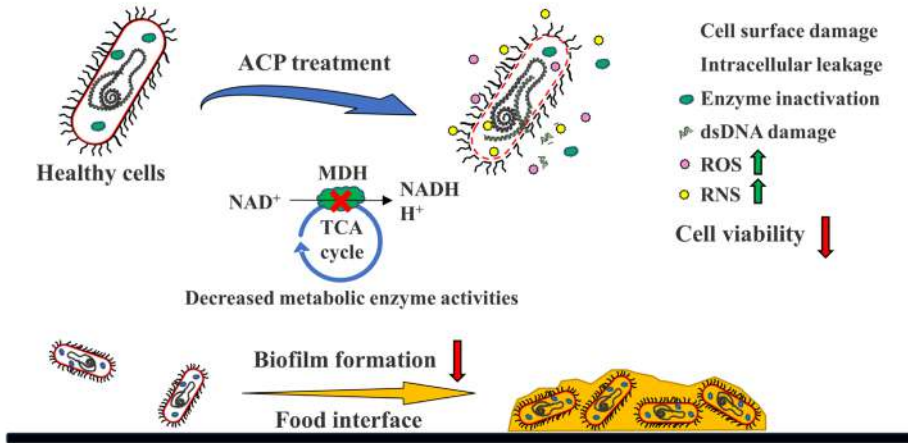


Fig. 5. Scheme diagram of antibacterial mechanism of *P. fluorescens* and *P. putida* during ACP treatment.

### 3.4 Correlation analysis and PLS-DA

Correlation analysis (Fig. 6A) revealed that RS levels ( $O_3$ ,  $H_2O_2$ ,  $NO_x$ , ROS) negatively correlated with bacterial viability, while  $O_3$  had the strongest impact ( $|r| > 0.95$ ). *P. fluorescens* showed greater sensitivity to RS than *P. putida*. PLS-DA (Fig. 6B-C) confirmed the influence of ACP duration on key parameters. VIP analysis identified dsDNA fluorescence and  $O_3$  as major contributors to bacterial inactivation.

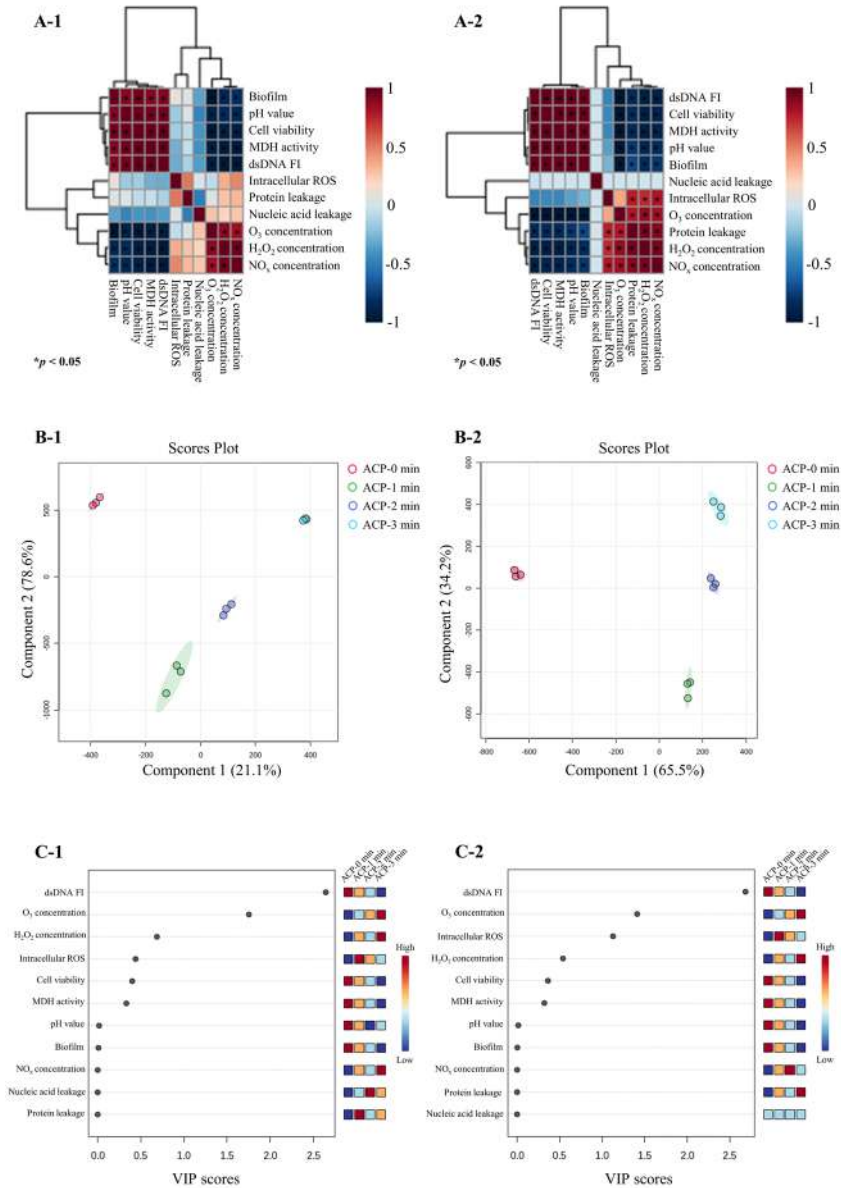


Fig. 6. The correlation analysis (A), two-dimensional score plot (B), and PLS-DA (C) of indexes in *P. fluorescens* and *P. putida* exposed to different ACP treatment time. A-1, B-1, and C-1 represented *P. fluorescens*. A-2, B-2, and C-2 represented *P. putida*.

### 3.5 Preservation effect of ACP treatment on red shrimp paste

ACP-treated shrimp paste showed reduced microbial loads and extended shelf life (Fig. 7).  $O_3$  declined rapidly post-treatment (half-life ~5-10 min), reacting with surface components. ACP reduced total viable count (TVC) and *Pseudomonas* by ~0.5-0.6 log CFU/g, with stronger effects on surface-associated *Pseudomonas*. By day 10, ACP-treated samples had TVC below the ICMSF limit (<7 log CFU/g), unlike controls. TVB-N levels were significantly lower in treated groups (20.91-23.94 mg/100 g) versus controls (>32 mg/100 g), indicating improved freshness. ACP disrupted microbial membranes via ROS/RNS, inhibiting spoilage without cooking. However, further studies are needed on ACP's impact on texture, nutrition, and microbial ecology.

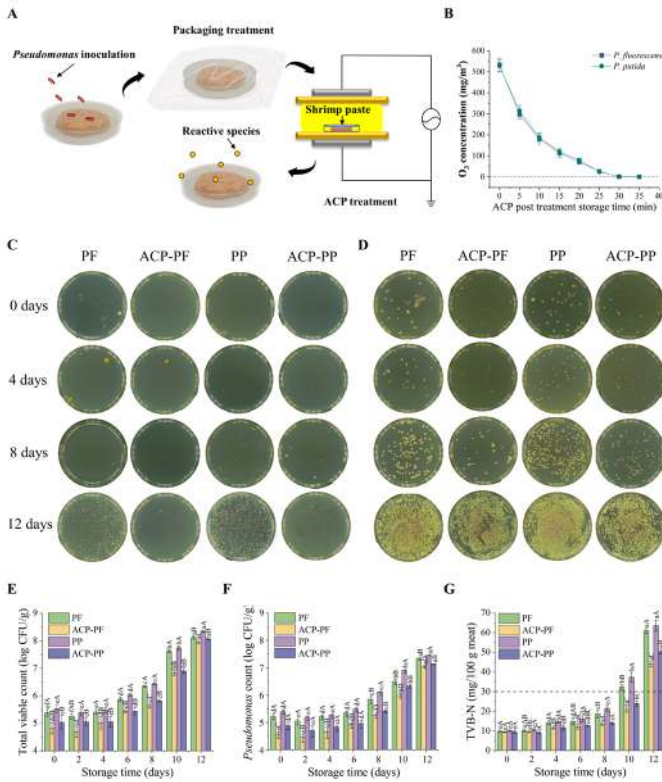


Fig. 7. Schematic diagram of shrimp paste treated by ACP (A), and changes in reactive species -ozone (B), plate count agar determination of total colonies (1 mL bacteria solution  $\times 10^{-4}$ ) (C), *Pseudomonas* CFC selective agar determination of *Pseudomonas* colonies (200  $\mu$ L bacteria solution  $\times 10^{-3}$ ) (D), changes in total viable count (E), *Pseudomonas* count (F), and TVB-N content (G) of shrimp paste inoculated with *P. fluorescens* or *P. putida*.

#### 4. Conclusion

In conclusion, the findings of this study demonstrated the effectiveness of ACP treatment in inhibiting the growth of *P. fluorescens* and *P. putida* in packaged shrimp paste. ACP-induced RS caused bacterial cells to undergo excessive oxidative stress, leading to cell membrane damage and intracellular substance leakage, ultimately resulting in microbial inactivation. Furthermore, ACP treatment significantly reduced the total viable and *Pseudomonas* counts in shrimp paste, thereby extending its shelf life and improving its microbiological quality. Overall, this study contributed valuable insights into the antibacterial mechanism of ACP against *Pseudomonas spp.* and its application in seafood preservation. Future research could focus on optimizing ACP treatment parameters, evaluating its impact on sensory attributes and nutritional quality of seafood products, and exploring its compatibility with other preservation techniques to further enhance the overall quality and consumer acceptance of seafood products. By addressing these areas, ACP has the potential to become a valuable tool for the seafood industry in ensuring food safety and meeting consumer demand for high-quality, shelf-stable seafood products.

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## INNOVATIVE SYSTEMS TO ENSURE FOOD SAFETY

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**Keywords:** food safety, CRISPR-based detection, loop-mediated isothermal amplification (LAMP), microbiological contaminant monitoring, rapid pathogen detection

Nowadays, ensuring food safety does not only mean providing food in quantity but also guaranteeing its quality. It is essential to make nutritious and sustainable food accessible to everyone. In this context, protecting consumers from the spread of foodborne diseases caused by the ingestion of pathogenic viruses and bacteria has a significant impact on public health and the economy of businesses. Providing the community with the ability to rapidly detect these contaminants is crucial for the common good. Foodborne diseases caused by the ingestion of viruses and pathogenic bacteria represent a significant and growing public health concern. In this context, analysing foods such as fresh and ready-to-eat (RTE) vegetables to detect these contaminants is crucial for ensuring food safety. The control of microbiological contaminants necessitates actions across the entire food chain, as every stage is susceptible to environmental or hygienic lapses. Effective monitoring of critical control points is a challenge, as highlighted by recent global outbreaks linked to non-animal-origin foods.

The control of microbiological contaminants requires monitoring actions across the entire production chain. Improving food safety also involves enhancing the control of production processes through rapid systems with extremely high sensitivity. However, current routine analysis methods often require highly specialized personnel and can take several days to produce results. Therefore, there is a pressing need for smart, versatile analytical methods capable of detecting and quantifying a wide range of pathogenic agents using a unified molecular approach.

Prompted by these considerations, we propose CRISPR-powered sensing strategies for detecting bacteria and nucleic acids. Our approach combines target detection with signal amplification, leveraging the collateral nuclease activity of the Cas12a system in a one-step assay. This ensures highly sensitive and specific detection.

Today, in collaboration with the Institute Superiore di Sanità (Rome, Italy) and the University of Tor Vergata (Rome, Italy), we are developing a system that, through

the combination of constant-temperature gene amplification techniques, such as Loop-Mediated Isothermal Amplification (LAMP), and innovative CRISPR-Cas-based detection technology, aims to support the identification of Salmonella in a single step (in less than one hour).

This, in turn, will improve food safety and quality, ensuring better consumer protection. It is easy to imagine that, thanks to its adaptability, this system could also be applied in clinical diagnostics to address critical challenges in human and veterinary health, ensuring health for all through a single diagnostic process. This project aims to advance emerging CRISPR technologies, transforming them into practical tools for food quality monitoring.

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## **FORUM 3**

### **Climate Change and Biodiversity**



## CLIMATE CHANGE AND BIODIVERSITY

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**Keywords:** transnational environmental governance, climate change modeling and monitoring, biodiversity-ecosystem interactions, remote sensing and earth observation, EU-China scientific collaboration

Environmental protection and green development are indeed high priorities in the current policies of the United Nations (UN), the European Union (EU), and China. This is linked to the growing attention of the scientific community regarding environmental issues, such as air and surface pollution, ecological degradation, and climate change. Awareness of these environmental concerns has spurred investment in green development aimed at achieving national environmental targets. In fact, environmental protection and green development are top priorities for the governments of Italy, EU, and China. To address their key national environmental objectives, these Entities are actively taking advantage of global policies, measures, and technologies to guide their efforts.

In particular, the recently completed (December 2024) EU-China Cooperation on Environment and Green Economy project (<https://www.clientearth.org/projects/eu-china-environment-project>), funded by the EU's Foreign Policy Instrument, supported EU-China cooperation on environmental policy to improve environmental protection standards and strengthen EU-China integration in environmental governance. The EU-China project organized bilateral thematic stakeholder workshops with the aim of: building trust and consensus between EU and China to; promoting mutual understanding of key environmental issues such as planning, monitoring, reporting, and review of national implementation of the GBF (Kunming-Montreal Global Biodiversity Framework at COP15 - <https://www.cbd.int/gbf>); analyzing the environmental impacts related to the climate change scenario. The stakeholder workshops output identified seven themes of common interest: Global Biodiversity Framework, Zero Deforestation, Plastics Management, Chemicals Management, Environmental Permitting, Integrated Environmental Policy for a Green Economy, and Global Environmental Governance. With specific regard to Biodiversity and Climate Change, the thematic workshops highlighted that biodiversity is a high priority

for the government in both China and the EU and that there is an urgent need to leverage finance for nature preservation.

Within this collaborative framework with China, various initiatives are being supported at both the EU and national levels, with the clear goal to strengthening EU-Italy-China relations in the areas of climate change and biodiversity. In particular, several noteworthy actions are active, the first supported by the European Space Agency (ESA) called the Dragon cooperation program (<https://earth.esa.int/eogateway/activities/dragon-cooperation-programme>), while at national level, two actions are supported by the Ministry of Foreign Affairs (MAECI) with the Ministry of Science and Technology of China (MOST) and by the National Research Council (CNR) in collaboration with the Chinese Academy of Sciences (CAS) (<https://www.cnr.it/it/accordi-bilaterali/accordo/54/cas-nuovo-accordo-chinese-academy-of-sciences>).

With regards the Dragon framework, the activities support the common exploitation of the ESA and Chinese Earth observation systems. Dragon 6, currently in progress, brings together over 55 EU-China scientific teams to discuss and analyze the enhancement of Earth observation data across a wide array of environmental issues, such as climate change, sustainable agriculture, water resources, ecosystems, atmosphere, cryosphere and hydrology, oceans and coastal zones, and urbanization and the environment. This is by taking advantage of the joint ESA and Chinese Earth observation system, which includes optical, infrared, thermal, and microwave sensors. Dragon 6 is currently in progress.

Concerning the ongoing bilateral initiatives between Italy and China (i.e. the MAECI-MOST and CNR-CAS/NFSC/MOST), collaborative research projects are active across various scientific topics.

On the MAECI-MOST call, several topics were jointly identified, ranging from biomedicine to AI to agriculture and food security. The selected collaborative projects will conclude their work in 2026, with a new call anticipated later this year.

The CNR-CAS call shows climate change and the environment as the main scientific theme. Within this theme, the project “Remote sensing techniques for monitoring crop growth and pests & diseases as related to climate change forcing” has been selected. The collaborative project, involving two leading institutes from CNR and CAS, aims to develop a high-precision, large-scale dynamic monitoring model for crop diseases and insect pests. This monitoring model will optimize the planning of water, fertilizer, and pesticide applications, promoting savings in these resources while safeguarding the ecological environment of farmland amidst the pressures of climate change. The selected collaborative projects are expected to conclude by 2026. New CNR-NFSC and CNR-MOST call will be closed for July 2025.

Within this Sino-Italian collaborative framework, Città della Scienza (<https://www.cittadellascienza-cina.it/>) has been supporting cooperation activities between Italy and China

in the fields of science, technology, and innovation for more than a decade. These activities have been carried out to bring the two countries closer and promote a permanent channel of cultural, scientific, and industrial exchanges. In November 2024, the XIII edition of the “Settimana Italia-China” was held to stimulate the exchange of experiences between Italian and Chinese teams on various topics. These working days were organized to create a facilitator to link the various stakeholders (e.g., research institutes and consortia or small companies) working on climate change topics. This objective was achieved by pooling competencies and case studies related to climate change and biodiversity in a plenary session.

In the XIII edition of the “Settimana Italia-China”, the “Climate Change and Biodiversity” plenary session attracted significant attention, with numerous presentations addressing key aspects of climate change and biodiversity in a plenary session with full participation. The session began with general cross-cutting observations to introduce the topics presented. The prologue highlighted that Climate Change refers to long-term changes in temperature and weather patterns. Human activities, particularly the burning of fossil fuels like coal, oil, and gas, are the primary drivers of climate change. Research on these topics is challenging, as it demands access to long-term, multi-source data at both global and local scales to analyze past, present, and future scenarios of the climate system and ecosystems. Collaborative efforts between countries aim to ensure stability and continuity of long-term time series measurements, as well as to develop approaches for data harmonization. The number of observations points essential for understanding and assessing the impact of climate change on Earth remains still limited. Additionally, this lack of data hampers progress in our understanding of the Earth’s climate system and the development of climate models capable of simulating changes with sufficient accuracy and uncertainty. New collaborative initiatives should be envisioned to establish multi-thematic and transnational observation networks useful for applying AI algorithms (with hybrid approaches also worth exploring) to retrieve state variables. These retrievals must account for uncertainties in the variables, which will then be integrated into climatological and ecosystem models.

During the plenary session, Italian and Chinese works on climate change modelling, resilience of urban drainage systems, carbon neutrality, energy consumption, oceans, biodiversity, and the impact of climate change on ecosystems were presented by eight eminent Chinese and Italian scientists. Additionally, the European Research Infrastructure (ERI) and the Principles of Findability, Accessibility, Interoperability, and Reusability (FAIR) were recalled to the audience. Overall, the presentations emphasized the interconnectedness of various scientific topics related to climate change and demonstrated how anthropogenic forces impact biodiversity. The following is a brief summary of the talks delivered by Italian scientists during the session.

Dr. Fiorentino presented the National Biodiversity Future Centre (NBFC), recently supported by the PNRR supporting action (<https://www.italiadomani.gov.it>). It focuses its

activities on biodiversity and climate change research. The center has created a functional network of 2000 biodiversity researchers (more than 600 young Phd), which is crucial for meeting modern challenges and EU demands. NBFC allows the population to get closer to the issues of biodiversity and Climate Change and to researchers to carry out their work, and businesses to find important opportunities for their development. The center is also supporting actions to build collaborations to promote international projects. Dr. G. Sannino talk regarded the impact of global “climate hotspots”, with average warming already 1.5°C above pre-industrial levels. At a planetary average, this is causing profound alterations in the region’s climatic and environmental balance, with direct effects on ecosystems, human activities and biodiversity. Dr F. Boero stressed that ecological transition requires a deep understanding of ecosystems and biodiversity. To achieve sustainability, we need a cultural revolution selecting ecology at the center of the analysis as it is an essential asset. Without the support of the natural assets, also economy will also collapse. Dr Boero states that our survival depends on the balance of ecosystems, and without the ocean, the Earth could not sustain life. Lastly, prof A. Basset observed that Climate change is causing alterations in the abiotic characteristics of ecosystems with direct effects on energy demands, living conditions and the interactions between living organisms. He observed that new research activities should be addressed to a deeper understanding of the responses of biodiversity and ecosystems to climate change and to the mitigation of their indirect impacts on the human ecosystem.

The talks facilitated a productive discussion between the audience and presenters on key questions raised during the talks. These questions could be briefly summarized in:

- Are carbon observation systems for the atmosphere, ecosystems, and oceans sufficiently widespread? Are they open access? What is their level of accuracy?
- Are there any development plans in Italy and China to expand or update monitoring networks?
- Which adaptation initiatives or enabling technologies could offer synergies to promote joint research activities?

The subsequent discussion highlighted that research on climate change, biodiversity, and ecosystem resilience is advancing rapidly within a diverse community that is tapping into talent like never before. One of the key challenges is optimizing energy use within community networks, an area where collaboration between research institutions, private and public companies, and stakeholders could be positively supported by future Chinese and Italian consortia. Local and regional future trends in energy transition and business innovation emerged as a topic with significant potential. In contrast, when it comes to ecosystem monitoring, the establishment of monitoring networks and data fairness were identified as key challenges. Hybrid approaches that combine physical models with AI appear to be the most effective way to predict ecosystem evolution. Finally, a discussion was sparked

on Earth digital twins – digital representations of the Earth system. These have met strong criticism, as they largely rely on physical models that cannot accurately mimic the physical ecosystem behavior but difficultly can predict impacts on living stocks.



## NATIONAL BIODIVERSITY FUTURE CENTER: RESEARCH, INNOVATION, AND SUSTAINABILITY

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**Keywords:** biodiversity research and monitoring, climate change mitigation, nature-based solutions, digital biodiversity gateway, green economy and innovation

The National Biodiversity Future Center (NBFC) is one of five national centers funded by the National Recovery and Resilience Plan (PNRR), focusing on biodiversity research and climate change mitigation. The center has established a functional network of 2,000 biodiversity researchers, essential for addressing modern challenges and meeting European Union requirements. Among these, over 600 young professionals, including PhD students, researchers, technologists, and fellows, are receiving training through the center.

NBFC's main legacy will be the Biodiversity Gateway, a hub where all center activities will converge. This digital platform, accessible via the World Wide Web, will also have two physical headquarters – one in Palermo and one in Venice, each with its specific focus. Through the Gateway, NBFC will allow the public to engage in biodiversity and climate change issues, provide researchers with opportunities to tackle emerging challenges and offer businesses significant development opportunities through access to new technologies and knowledge.

To promote competitiveness and bring NBFC's innovations to the market, several initiatives will be launched, including:

- Start-Up Studio, aimed at supporting the creation and consolidation of businesses in the green economy sector and fostering green jobs.
- Project Design Studio, which will facilitate collaborations and funding acquisition for international projects.

NBFC will also provide technical and scientific support to institutions responsible for addressing environmental and biodiversity challenges.

Biodiversity is not just an environmental issue – it is the very foundation of life on our planet and is currently facing an unprecedented crisis. The effects of climate change are becoming increasingly evident and devastating, and the loss of biodiversity – accelerated by human activities – poses risks to our health, economy, and ecosystem stability.

It is within this context that the National Biodiversity Future Center (NBFC) was established – one of the five PNRR-funded national centers dedicated to biodiversity research and the fight against climate change. The creation of NBFC demonstrates Italy's commitment to addressing these global challenges.

With a network of around 2,000 researchers, including over 600 young professionals (PhD students, researchers, technologists, and fellows), NBFC is a true national center of excellence in the field of biodiversity. The center not only promotes research but also serves as a reference point for environmental sustainability policies and biodiversity practices in Italy and Europe.

At the European level, two major policies have been adopted for nature conservation:

- The European Green Deal, which aims for climate neutrality by 2050.
- The Nature Restoration Law, which requires member states to restore at least 20% of degraded ecosystems.

NBFC provides scientific and technological support to help implement these directives through tangible, measurable actions, engaging stakeholders and citizens.

One of NBFC's most significant early contributions is the Annual Biodiversity Report, which provides a comprehensive and up-to-date overview of the state of Italy's natural heritage, highlighting challenges and defining potential strategies for ecosystem conservation, biodiversity monitoring, and restoration.

Additionally, the center has carried out an extensive digitization effort, making biodiversity knowledge widely accessible. This includes:

- 1.5 million museum specimens cataloged.
- At least 5,000 DNA samples from plants and animals.
- Thousands of bioactive molecules with potential applications in medicine, cosmetics, and food production.

This digital database is accessible to the international research community, positioning Italy at the forefront of biodiversity research and Biodiversity Informatics technologies. This initiative is a concrete example of how technology can be applied to protect and enhance our natural heritage.

## **1. Nature-Based Solutions & Marine Conservation**

To increase biodiversity, NBFC has developed a catalogue of Nature-Based Solutions (NBS), collecting over 70 solutions inspired by nature to restore degraded environments, and create green oases, coastal protection barriers, ecological corridors, and wetland areas. These projects:

- Improve urban aesthetics and livability.

- Help mitigate climate change impacts by reducing temperatures and improving air and water quality.

Another key initiative is the Marine Geoportal, an innovative platform connecting marine biodiversity and sea usage. This tool will support coastal authorities, marine protected area managers, and other stakeholders in better managing the Mediterranean ecosystem.

## **2. Education & Business Development**

Beyond research, NBFC is actively engaged in training future professionals through programs like:

- Master in One Health, an innovative and integrated training program on human, animal, and environmental health – demonstrating the interconnectedness of planetary health.
- Training for taxonomists, equipping experts with biodiversity knowledge.
- UPSKILLING Program, supporting young entrepreneurs in developing business ideas focused on biodiversity and climate change, thus driving the green economy.

## **3. International Collaborations**

From its inception, NBFC has fostered strong international partnerships to tackle environmental challenges collectively. Key collaborations include:

- Integrated Carbon Observation Systems (ICOS): NBFC is developing predictive models and data analysis systems to better understand greenhouse gas trends and improve climate strategies.
- The Chinese Academy of Sciences: Italy and the Ministry of the Environment (MASE) have conducted over 30 nature conservation projects, and NBFC aims to enhance this collaboration through technological innovations for biodiversity monitoring and nature restoration.

NBFC has also worked closely with the OECD's Technology and Innovation Policy Group, leading to the launch of the "Harnessing Innovation in Biodiversity" project, which gathers and shares global best practices for integrating biodiversity into innovation policies.

As a recognition of its impact, NBFC was invited to COP16 in Cali, Colombia, where it contributed scientific expertise to evaluate progress on biodiversity commitments set during COP15 in Montreal (2022).

## **4. Biodiversity Gateway: A Lasting Legacy**

All these projects and achievements are consolidated within the Biodiversity Gateway, the

primary legacy of NBFC. This digital and physical hub (with offices in Palermo and Venice) allows the public to access crucial biodiversity and climate change information, while also providing researchers and businesses with tools for process and product innovation.

Gateway serves multiple functions:

- A training platform for green job professionals.
- A support system for territorial management and business development.
- A launchpad for new sustainable enterprises, through initiatives like Start-Up Studio and Project Design Studio, which help create green jobs and foster international sustainability partnerships.

Through the Biodiversity Gateway, NBFC provides a tool for citizens to explore Italy's biodiversity, raising awareness and engagement in environmental values. Public participation is crucial for biodiversity conservation and climate action, and NBFC is achieving this through initiatives like:

- The exhibition “Elogio della Diversità – A Journey Through Italian Ecosystems”, was inaugurated on November 26 at the Palazzo delle Esposizioni (Rome).
- “NBFC & National Geographic” Photo Exhibition, showcasing the beauty of Italian biodiversity, running from January to April 2025, with special educational programs for school students.

## 5. Conclusion

NBFC is not just a research center – it is a symbol of Italy's commitment to a sustainable future. It represents a model of collaboration between science, institutions, and industry, proving that meaningful change is possible when knowledge and resources are shared with the global community.

We face immense challenges, but with initiatives like NBFC, we can make a difference.

At NBFC, we have a phrase: “Biodiversity is the Solution”. Biodiversity is not just something to protect, it is a resource to enhance a new, sustainable, and healthy economy, ensuring a better planet for future generations.

# HUMAN FACTOR INTEGRATION IN CITY DRAINAGE SYSTEM RESILIENCE UNDER EXTREME WEATHER INFLUENCE

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**Keywords:** urban drainage system resilience, extreme weather risk management, human reliability analysis, climate change and biodiversity, man-machine environment interaction

## 1. Introduction

In February 2022, the Chinese government issued the 14<sup>th</sup> Five-Year Plan for the National Emergency System (*National Emergency System to Be Improved*, 2022). This plan responds to climate change and emphasizes the development of comprehensive multi-disaster monitoring and early-warning systems by 2025. Urban drainage systems, a critical part of city infrastructure, are particularly vulnerable to the increasing frequency of extreme weather events. The stormwater management systems of long-aged cities tend to afford degrading storm drainage infrastructures, poor predictive capabilities, prolonged recovery periods, and limited adaptability to emerging situations. In the same way, traditional methodologies in the risk management domain, which often overlook the human factors and the interactions among system elements, failed to capture the critical complex social-technical systems' features.

Trying to bridge these gaps, this study aims to develop a holistic framework for promoting the resilience of urban drainage systems under extreme weather conditions. Based on the Integrated Dynamic Decision Analysis (IDDA) approach<sup>1</sup>, the research identifies sensitive operational conditions in stormwater drainage infrastructure. It analyzes how these conditions interact with human error patterns, such as cognitive overload and task misjudgment. The project investigates the compound effects of system fragility and human factors, constructs a dynamic risk model, and develops intelligent monitoring tools to support early warning and real-time risk management. Ultimately, the research contributes

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<sup>1</sup> DEMICHELA, PICCININI 2004, 2956-2961.

to theoretical modeling and practical risk governance by integrating human-machine-environment (HME) interaction mechanisms into urban drainage system resilience strategies.

## 2. Methodology

This research's methodological framework is grounded in the Integrated Dynamic Decision Analysis (IDDA) approach, which systematically evaluates system reliability by integrating physical infrastructure dynamics with human performance factors. The study first constructs a multi-hazard model based on real-world data from drainage infrastructure systems under extreme weather conditions. Key system vulnerabilities are identified using fault tree analysis (FTA) and event sequence modeling to examine failure propagation across subsystems.

Human reliability is assessed using scenario-based simulations and cognitive task analysis. This technique includes modeling operator decision-making under time pressure, fatigue, and uncertainty, common during extreme weather-induced crises. A dynamic human-machine-environment (HME) interaction model is applied to explore how human actions, technological feedback, and environmental stressors interact to produce system-wide outcomes. This model supports the generation of accident causation chains, identifies latent conditions contributing to risk, and predicts cascading failures.

To better apply the findings, software tools are being developed that visualize system vulnerabilities and offer early-warning alerts based on integrated sensor and operational data. These tools support real-time decision-making and preemptive intervention in urban drainage network operations.

## 3. Case Background: Zhengzhou Rainstorm Disaster

The July 20, 2021, rainstorm in Zhengzhou, Henan Province, is one of the most severe urban climate-related disasters in recent Chinese history. Over 200 mm of rainfall fell in one hour, exceeding the historical average for the entire month. The deluge overwhelmed the city's drainage capacity, leading to widespread flooding, power outages, transportation paralysis, and the tragic loss of more than 300 lives.

A comprehensive post-disaster assessment revealed multiple layers of system failure<sup>2</sup>. The physical drainage infrastructure was underdesigned for such a rare extreme event. Some errors occurred when rebuilding the disaster scenario models. Signal disruptions in the "urban brain" digital monitoring platform led to delays in emergency responses. Critically, human operators were unprepared to respond effectively under such novel and complex

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<sup>2</sup> MANANDHAR *et al.* 2023.

conditions. Task misallocations, delayed decision-making, and communication breakdowns exacerbated the consequences. The total direct economic loss exceeded ¥120.06 billion, underlining the devastating social and financial impact of insufficient system resilience and human preparedness.

This case provides a data-rich context for evaluating the interaction between components of social-technical systems. It demonstrates the urgent need for integrated approaches that address technical and human-centered vulnerabilities.

#### **4. Results and Implications**

The project contributes theoretically by integrating risk science and human reliability analysis into a unified framework for evaluating drainage system resilience under extreme weather. It also offers methodological innovations by extending the IDDA model to incorporate human error as a dynamic component in system vulnerability assessments. This approach enables the identification of high-risk scenarios in which human behavior and environmental uncertainty interact to produce cascading failures.

The research offers a replicable model for enhancing the operational safety of complex urban systems. The proposed monitoring tools and early warning systems have significant social implications. Specifically, these tools help mitigate social and economic losses by enabling pre-disaster risk identification and real-time decision support during emergencies. Thus, the project provides theoretical and applied pathways toward building more resilient cities in the face of climate change.

#### **5. Acknowledge**

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## MEDITERRANEAN CLIMATE: A HOTSPOT UNDER PRESSURE

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**Keywords:** climate hotspot, regional earth system modeling (esms), extreme weather and marine heatwaves, mitigation and adaptation strategies, water scarcity and desertification risk

The Mediterranean region is recognized by the scientific community as one of the major global “climate hotspots”<sup>1</sup>, a designation that underscores its extreme vulnerability to climate change impacts. Positioned between Europe, Asia, and Africa, the Mediterranean basin exhibits a unique combination of geographical and climatic factors that make it particularly sensitive to rising global temperatures<sup>2</sup>.

Historically, the Mediterranean climate has been relatively predictable, characterized by hot, dry summers and mild, rainy winters without significant extremes. However, global warming is destabilizing this equilibrium. One of the most evident signs is the rise in temperatures. Scientific evidence clearly indicates that, compared to pre-industrial levels, average temperatures in the Mediterranean region have already increased by 1.5°C, exceeding the global average by approximately 0.4°C<sup>3</sup>. This warming rate, faster than in many other regions, is an early indicator that the Mediterranean is undergoing climatic transformations that will have profound consequences on ecosystems and human activities.

To better understand these dynamics, climatologists use sophisticated mathematical models known as Earth System Models (ESMs), which integrate all components of the Earth’s climate system, from the atmosphere to the oceans, ice, vegetation, and biogeochemical cycles<sup>4</sup>.

ENEA (the Italian National Agency for New Technologies, Energy, and Sustainable Economic Development) contributes to the development of the global ESM EC-Earth and has developed a regional ESM (ENEA-REG) specifically for the Mediterranean area<sup>5</sup>.

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<sup>1</sup> GIORGI 2006, 33(8).

<sup>2</sup> TUEL, ELFATIH 2020.

<sup>3</sup> *Mediterranean Experts on Climate and Environmental Change* (MedECC) 2020.

<sup>4</sup> DÖSCHER, ACOSTA, ALESSANDRI *et al.* 2022.

<sup>5</sup> ANAV *et al.* 2021.

The scenarios outlined by ENEA<sup>6</sup> for the Mediterranean vary depending on different greenhouse gas emission levels<sup>7</sup>. In a low-emission scenario, assuming a decisive global effort to reduce emissions and achieve carbon neutrality by mid-century, temperature increases are projected to range between 1.5°C and 2°C above pre-industrial levels. However, more pessimistic scenarios, characterized by continued emissions growth, indicate a potential rise of up to 4-5°C by the end of the century.

Another critical aspect of climate change in the Mediterranean concerns precipitation patterns. Studies conducted by ENEA<sup>8</sup> indicate a significant decline in annual rainfall, particularly during summer months. In high-emission scenarios, this reduction could reach up to 30%, significantly increasing the frequency and intensity of drought periods. In some cases, this could lead to progressive desertification in large areas of Southern Europe and North Africa.

In low-emission scenarios, precipitation reductions will be less drastic but still noticeable, with an estimated decrease of 5-10% compared to current levels.

These changes in precipitation, combined with rising temperatures, will make the Mediterranean particularly vulnerable to water shortages, biodiversity loss, and an increased risk of wildfires, also affecting key economic sectors such as agriculture and tourism<sup>9</sup>.

Another consequence of climate change in the Mediterranean is the increase in extreme weather events. Heatwaves, wildfires, and torrential rainfall are becoming more frequent. To further complicate the situation, marine heatwaves (MHWs), and prolonged warming events of surface waters, have also been recorded<sup>10</sup>.

The impacts of climate change are not limited to the natural environment but also affect the region's society and economy. The Mediterranean is home to approximately 500 million people, many of whom reside along the coasts. Rising sea levels threaten coastal cities and infrastructure<sup>11</sup>, while reduced water availability and declining agricultural productivity could trigger tensions among Mediterranean countries, increasing the risk of climate-induced migrations. Coastal communities, in particular, will face growing risks, with sectors such as tourism severely affected.

The Mediterranean serves as a natural laboratory for studying climate change impacts. Given these unprecedented challenges, it is crucial to distinguish between mitigation and adaptation strategies. Mitigation refers to actions aimed at reducing or preventing

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<sup>6</sup> ANAV *et al.* 2024.

<sup>7</sup> IPCC 2021.

<sup>8</sup> ANAV *et al.* 2024.

<sup>9</sup> *Mediterranean Experts on Climate and Environmental Change* (MedECC) 2020.

<sup>10</sup> DARMARAKI *et al.* 2019, 1637-1656.

<sup>11</sup> SANNINO *et al.* 2022, 357-391; CAPPUCCI *et al.* 2024.

greenhouse gas emissions and addressing the root causes of climate change. Without effective mitigation measures, adaptation strategies risk being inadequate or temporary.

A coordinated and global approach is necessary to mitigate the most severe effects of climate change in the Mediterranean. This includes adopting ambitious climate policies, transitioning to renewable energy sources, and promoting sustainable practices across all economic sectors. Only by establishing solid mitigation measures can we create the foundation for effective adaptation strategies, which include sustainable water resource management, the adoption of innovative agricultural techniques, and the development of resilient infrastructure capable of withstanding extreme climatic events. Additionally, investments in research and advanced technologies for monitoring and forecasting climate changes will be essential for effective adaptation.

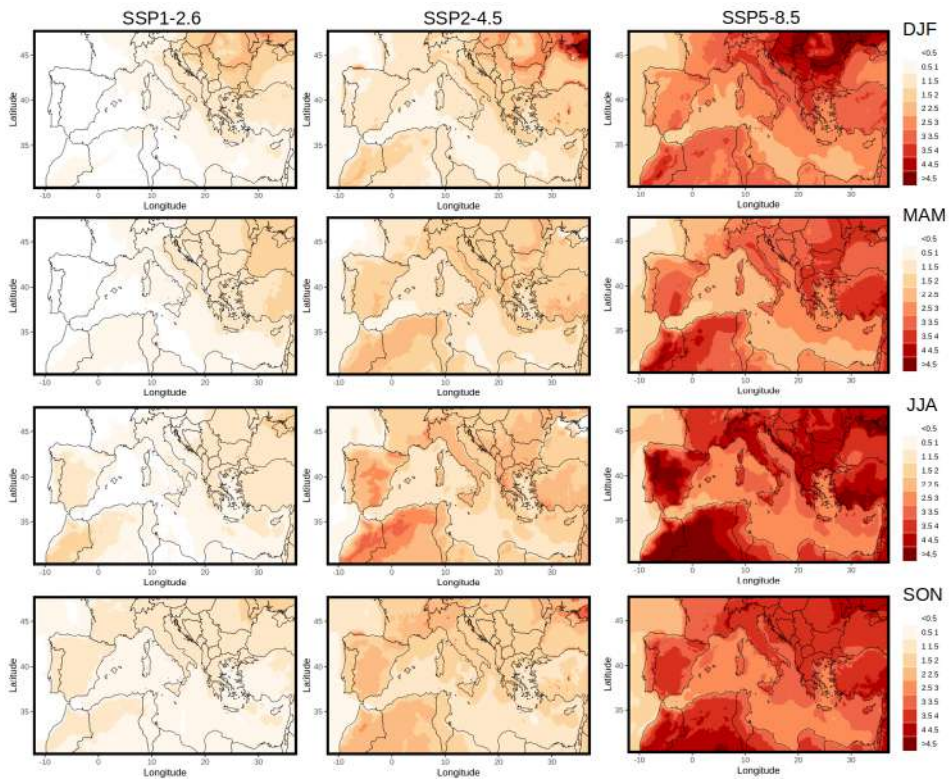


Fig. 1. Change in surface temperature (°C) at the end of the century compared to the historical period (2071-2100 minus 1985-2014), calculated from simulations performed with the ENEA-REG model: SSP1-2.6 (left column), SSP2-4.5 (central column), and SSP5-8.5 (right column). Winter (December-January-February, first row), spring (March-April-May, second row), summer (June-July-August, third row), autumn (September-October-November, fourth row). From Anav et al. (2024).

The future of the Mediterranean will depend on our ability to innovate and reconsider our relationship with the environment, integrating both mitigation and adaptation measures. Only in this way can we preserve not only the region's natural heritage but also its cultural and historical legacy, ensuring the resilience of one of the most unique areas on our planet.

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# TECHNOLOGY EMPOWERMENT FOR KUNMING-MONTREAL GLOBAL BIODIVERSITY FRAMEWORK CITY PARTNERSHIP PROGRAM

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**Keywords:** urban biodiversity conservation, technology-enabled ecological monitoring environmental DNA (eDNA) applications, nature-based urban restoration, public engagement and policy integration

## 1. Introduction

Biodiversity, the lifeblood and foundation of the Earth's life community, is essential for human survival and development. However, with the acceleration of urbanization, biodiversity is facing unprecedented challenges. Habitat loss, invasive alien species, environmental pollution, and climate change are causing a rapid increase in global species extinction rates and a significant decline in ecosystem service functions<sup>1</sup>. In this context, urban biodiversity conservation has become particularly important and urgent.

## 2. The Significance of Urban Biodiversity Conservation

Urban biodiversity refers to the degree of differentiation in genes, species, and urban ecosystems among various non-human biological entities within the urban area. It not only reflects human culture but also helps improve the quality of life in an increasingly urbanized society. Urban biodiversity is often the only biodiversity that most humans can experience, and thus it is frequently used as an important indicator to evaluate the ecosystem service functions and the quality of the urban ecological environment<sup>2</sup>. Incorporating diverse intelligent research tools will significantly enhance the conservation of urban biodiversity<sup>3</sup>. Protecting urban biodiversity is of great significance for maintaining urban ecological security and balance, as well as improving the urban living environment.

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<sup>1</sup> MCDONALD *et al.* 2008, 1695-1703.

<sup>2</sup> ERICKSON *et al.* 2020, 178-188.

<sup>3</sup> ZHAO *et al.* 2022.

The Yunnan International Joint Center of Urban Biodiversity was officially established in 2024, comprising the Kunming Institute of Zoology of the Chinese Academy of Sciences, Southwest Forestry University, Souphanouvong University of Laos, and Yunnan Xinxing Greening Engineering Co., Ltd. The center is committed to the conservation and sustainable management of urban biodiversity.

From its inception and subsequent establishment, the Yunnan International Joint Center of Urban Biodiversity has been steadfastly engaged in efforts encompassing urban biodiversity conservation, biodiversity monitoring, nature-based ecological restoration, eco-friendly prevention and control of invasive alien species, bio-friendly landscaping design, artificial intelligence application, and rapid species identification<sup>4</sup>.

### 3. Practices in Urban Biodiversity Conservation

In recent years, we have carried out a series of urban biodiversity conservation practices in Kunming's Cuihu Park and achieved some results. The following sections will present these outcomes from several perspectives.

#### 3.1 Establishing an Urban Biodiversity Demonstration Area

Kunming was once a “water city” like Venice. Cuihu Park, as an oasis left behind by Dianchi Lake, the largest of Yunnan’s nine plateau lakes, situated in the center of Kunming,



Fig. 1. Using Natural Solutions to Restore and Protect Cuihu's Bird Island.

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<sup>4</sup> FRANCINI *et al.* 2022, 1258-1274.

is an important area for urban wetland biodiversity conservation. An urban biodiversity demonstration area has been established in this location to protect the habitats of urban wildlife. Through the construction of urban landscape diversity with “animals + plants + microorganisms”, the ecological environment of Cuihu Park has been effectively improved, and biodiversity has been significantly enhanced.

### 3.2 Species Protection and Restoration Plans

Protection and restoration plans have been developed for key species in Cuihu Park. For example, for native species such as the black-water chicken, egrets, grey herons, and cattle egrets, ecological restoration measures have been implemented to provide suitable habitats. At the same time, efforts to strengthen the prevention and control of invasive alien species have been undertaken, utilizing techniques such as environmental DNA monitoring to detect and remove invasive species in a timely manner, thereby protecting native biodiversity.



Fig. 2. Invasive Species Management and Control.

### 3.3 Ecosystem Management

The management and protection of the Cuihu Park ecosystem have been strengthened. Through scientific land-use planning, reducing pollution emissions, and conserving water resources, efforts are focused on improving the stability and service functions of the ecosystem. At the same time, the protection and management of important ecosystems, such as wetlands and urban landscapes, have been reinforced, providing a solid ecological foundation for urban biodiversity.



我是与凡花不同的高冷美人  
“山中隐士的馈赠”

红花深山含笑不仅是生态系统的贡献者，更在经济、文化领域展现多维价值。其独特的花色和香气及适应性使其成为科研与园艺的热点，而深厚的文化内涵则为地方传统注入自然之美。保护和可持续开发这一珍稀变种，传统中医用于治疗花蕾缓解焦虑、疏肝解郁；对生态与人文均具有重要意义。

红花深山含笑为木兰科含笑属，是深山含笑的一个变种。其与深山含笑主要区别在于花略小，花色偏红，心皮连柱头呈紫红色，香气清幽。作为蜜源植物吸引传粉昆虫（如蜜蜂、蝴蝶），果实为红色，7~8月份是鸟类喜欢的食物，促进生物多样性发展。其花、叶和树皮可提取挥发油，可作为香料和药物的材料；又因其树形优美，枝叶繁茂，花香浓郁，病虫害少，深根系可固土防滑坡，改善局部水土保持。在国内已经广泛栽培，是优良的观赏树种，经过十多年选育我们杂交驯化已培育出优良新品：“云林醉舞”、“云林醉舞”已获云南省园艺植物新品种认定及云南省林木良种认定。

红花深山含笑

Fig. 3. Ecological Restoration with Indigenous Plants.

### 3.4 Education and Publicity Activities

To raise public awareness and the importance of urban biodiversity conservation, our center has conducted a large number of educational and publicity activities by organizing science lectures, exhibitions, training sessions, and other activities to popularize knowledge on



Fig. 4. Hundred Birds Science Popularization Exhibition.

biodiversity conservation among the public and advocated for environmentally friendly lifestyles. At the same time, media platforms have also been used to widely disseminate the importance of biodiversity conservation in order to create a favorable social atmosphere.

#### 4. Technology Empowerment for Urban Biodiversity Conservation

In the biodiversity conservation practices of Cuihu Park, we have fully leveraged technological means to empower conservation efforts. Several key aspects of these technological applications are outlined below:

##### 4.1 AI Smart Bird Monitoring and Recognition System

To more efficiently monitor the dynamics of bird populations in Cuihu Park, the Yunnan International Research and Development Center for Urban Biodiversity – in collaboration with the Institute of Semiconductors of the Chinese Academy of Sciences – has developed an AI smart bird monitoring and recognition system. This system captures bird images through high-definition cameras and uses deep learning algorithms to automatically identify and analyze the images. Currently, the system can recognize multiple bird species in Cuihu Park and monitor their numbers and distribution in real-time. The application of this technology has greatly improved the efficiency and accuracy of bird monitoring, providing strong data support for conservation efforts.



Fig. 5. AI Bird Species Identification System.

#### *4.2 Environmental DNA Monitoring Technology*

Environmental DNA monitoring technology is an emerging biodiversity monitoring method. By collecting DNA fragments from environmental samples such as water and soil, it becomes possible to analyze the species information contained in the samples, thereby enabling rapid monitoring and assessment of biodiversity. In the prevention and control of invasive alien species in Cuihu Park, we have successfully used environmental DNA monitoring technology to detect the presence of multiple invasive species and taken corresponding prevention and control measures in a timely manner. The application of this technology has provided new ideas and methods for the prevention and control of invasive alien species.

#### *4.3 High-Throughput Barcoding and Environmental DNA Techniques*

To further enhance the efficiency and accuracy of biodiversity monitoring, high throughput barcoding and environmental DNA techniques were also introduced for common urban species. High-throughput barcoding technology allows for rapid and accurate species identification of a large number of samples, while environmental DNA techniques can assess the status of biodiversity by analyzing DNA information in environmental samples. The application of these technologies has provided richer and more accurate biodiversity data support, offering a more scientific basis for conservation efforts.

### **5. Future Prospects for Urban Biodiversity Conservation**

Although we have achieved some results in urban biodiversity conservation, the tasks ahead remain arduous. To further advance the protection of urban biodiversity, efforts are required in the following areas:

#### *5.1 Strengthening Policy Formulation and Implementation*

Cooperation with governments at all levels is essential to increase investment in urban biodiversity conservation and participate as experts in work related to invasive alien species prevention and control, green and beautiful city construction, and major projects. By popularizing laws and regulations with government departments, strengthening supervision and evaluation of policy implementation, it will be possible to promote the effective implementation of policy measures for urban biodiversity conservation within the Kunming demonstration area.

### 5.2 Promoting Technological Innovation and Application

Technological innovation is an important driving force for urban biodiversity conservation. Continued efforts are needed to strengthen technological innovation by developing more efficient and accurate monitoring technologies and protection methods. At the same time, the conversion and application of technological advancements should be actively promoted to convert research outcomes into actual productivity.

### 5.3 Enhancing Public Participation and Education

The public serves as a pivotal force in urban biodiversity conservation. The Yunnan Ripple Model underscores the imperative to amplify public engagement and environmental literacy, fostering widespread awareness of the critical role urban biodiversity plays in sustaining livable cities. By empowering citizens as co-creators of conservation solutions through participatory science, community-led restoration projects, and eco-literacy campaigns we can catalyze a societal shift toward collective stewardship, transforming urban spaces into vibrant mosaics where humans and nature thrive in harmony.



Fig. 6. “Ripple of Yunnan’s Urban Biodiversity” Enhancing Public Participation and Education.

### 5.4 Strengthening International Cooperation and Exchange

Urban biodiversity conservation is a global issue. Strengthening cooperation and exchange with the international community is essential to jointly promote global biodiversity conservation efforts. By sharing experiences, exchanging technologies, and other means, we can better address the challenges and issues faced by urban biodiversity conservation.

## 6. Conclusion

Biodiversity conservation is a long-term and arduous task. As explorers and practitioners of urban biodiversity conservation, we will continue to uphold the spirit of science, innovation, and cooperation, constantly driving the development of urban biodiversity conservation efforts. The case featuring Kunming's Cuihu Park as an urban model is one of the projects undertaken by the Yunnan Provincial International Joint Research and Development Center for Urban Biodiversity, and it has been selected as a global promotional example for the United Nations World Cities Day 2024. At the same time, we also call on people from all sectors of society to pay attention to and support urban biodiversity conservation work, contributing to the construction of a shared Earth life community.

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# HOW THE WORLD WORKS

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**Keywords:** natural capital and ecosystem services, oceanic climate regulation, marine biodiversity and ecosystem functioning, ecological literacy and sustainability transition, anthropogenic pressures and systemic feedback

## 1. Our well-being is based on the natural capital

Our existence, like that of all species, depends on the goods and services provided by biodiversity and ecosystems. The growth of the human population and our current production and consumption systems are undermining the premises for future prosperity. The energy we use continues to be produced through combustion processes – we started with wood and coal, then passed to oil and gas – continuously releasing excess carbon dioxide into the atmosphere, driving climate change toward states increasingly unfavorable to us.

## 2. Two climates?

Ocean water temperature determines the climate: when ocean water evaporates or freezes, it leaves salts behind in the remaining liquid portion, since both vapor and ice are fresh water. Atmospheric climate is governed by currents that move water, in the form of perturbations, over oceans and continents, while oceanic climate is characterized by currents that circulate water within ocean basins. The production of carbon dioxide through combustion processes influences oceanic evaporation and freezing, which in turn affects atmospheric climate, setting off a series of feedback loops that alter both planetary climates.

## 3. 90% is ocean

The planet is alive thanks to the ocean, which covers 71% of its surface. However, the ocean is a volume: multiplying that 71% of the surface by the average ocean depth reveals

that more than 90% of the life-inhabited space on Earth is ocean – mostly dark, where photosynthesis is impossible. So how is oxygen present in deep waters, where there are no plants to produce it and only animals that consume it?

#### **4. The great ocean conveyor belt**

The formation of sea ice connects the oceans into a single system. When seawater freezes, the “fresh” ice floats, while the remaining cold, salty water becomes denser and sinks, carrying oxygen produced by marine vegetation and exchanges with the atmosphere to the depths.

Deep waters formed at the surface in the Arctic descend southwards along the Atlantic, reaching the South Pole, where ice formation causes more surface water to sink. A deep current circles Antarctica, with two branches flowing northwards toward the Indian Ocean and the Pacific Ocean respectively. These branches eventually rise to the surface, warm up, and return to Antarctica, then flow northwards toward the Atlantic and reach the Arctic. This process creates the great ocean conveyor belt. Global warming is altering both oceanic and atmospheric climates by disrupting ice formation and evaporation. The melting of polar ice releases fresh, cold water, which alters the warm surface currents of the conveyor belt, modifying the ocean’s ability to regulate the climate. Increased oceanic evaporation in warmer regions generates increasingly intense storms. Everything is interconnected, with each event triggering cascades of additional events.

#### **5. Marine ecosystems and biodiversity**

The physics of the great ocean conveyor explains how water masses are connected and how oxygen is transported to the depths, sustaining life across much of the planet. However, when we move from physics to biology, our ignorance is vast.

Marine ecosystems function differently from terrestrial ones. Most inhabitants of the immense ocean do not interact with the seafloor but live suspended in the water column. The species we recognize – from sharks and whales to fish, penguins, jellyfish, and squid – are carnivores. How can ecosystems exist where most organisms are carnivores that eat each other? Where are the plants?

While algae and marine plants thrive along coasts where sunlight reaches, they do not sustain the vast open ocean ecosystems. What supports these ecosystems, which appear dominated by carnivores? The answer lies in biological cycles.

All fish develop from tiny eggs that grow into embryos, larvae, and juveniles before reaching adulthood. From tuna to anchovies, everything begins with tiny organisms that, once grown to various sizes, prey on each other. However, nearly all juveniles feed on small

planktonic crustaceans, especially copepods, which are herbivores consuming microscopic algae – the “plants” of the ocean.

The planktonic community of copepods and microscopic algae sustains the massive population of carnivores, which could not survive without them. Decomposing bacteria break down dead organisms and waste, regenerating nutrients that fuel new algal photosynthesis. What is produced in the sunlit zone eventually sinks into the dark depths, forming marine snow, composed of organic debris from surface life.

In the absence of herbivores, deep-sea ecosystems rely on detritus-feeders at the base of food webs only apparently carnivore-dominated.

### 5.1 *The ocean governs life*

More than 90% of the biosphere functions this way:

- Copepods are the most important animals on the planet.
- Microscopic algae are the most important plants.
- Decomposing bacteria are the most crucial organisms of all – without them, ecosystems could not renew themselves.

Everything is interconnected: biodiversity (structure) ensures ecosystem functioning.

## 6. The knowledge we need

We are altering the planet, making it increasingly inhospitable for ourselves. Scientists warn about the consequences of unsustainable production and consumption systems. We have never lived as comfortably as we do today, but we do so by accumulating a debt with nature.

The Marine Strategy Framework Directive of the European Union aims to achieve Good Environmental Status, based on marine biodiversity and ecosystem health. The true measure of sustainability is the state of biodiversity and ecosystems. Unfortunately, our understanding of biodiversity and ecosystem functioning remains rudimentary. We have described only two million species, while estimates suggest at least ten million exist. How can sustainability policies be based on incomplete knowledge of the systems that sustain us?

Biodiversity and ecosystem health must be the benchmark for assessing the effectiveness of all political and economic sustainability initiatives. We must “transit” toward ecological awareness.

### 6.1 *Ecology is political*

- Societies and economies cannot exist independently of environmental systems, which must be properly valued.

- The economic capital only exists if supported by natural capital. Without nature, the economy collapses.
- When nature is fatally wounded, it wins – by overwhelming those who harm it and evolving in a different direction, as has happened at least five times in Earth's history.

Our well-being depends on the state of the planet. The world will endure the impacts of human activity, but it will shift to different states, which may be unfavorable to us. A cultural revolution is urgently needed: without knowledge of the natural world, we cannot develop effective sustainability policies. The ecological transition requires ecological literacy. Education systems fail to provide the fundamental cultural knowledge needed to understand how the world is structured and how it functions. Ignorance is ruining the planet.

We must build a culture that includes nature, giving priority to the seas and oceans. Without the ocean, the world dies. Through the water cycle, rainfall that sustains life on land originates from ocean evaporation. Without the ocean, the planet dies.

## 7. The path to sustainability

- Complete the inventory of biodiversity.
- Understand the role of species in ecosystem functioning.
- Study the ecological relationships linking species and their physical environment.
- Frame biodiversity and ecosystems within a spatial-temporal context.
- Plan human activities based on deep knowledge of natural capital.

Mismanagement stems from poor understanding of natural systems and the consequences of our actions on their structure and function. Historically, human pressures were confined to terrestrial ecosystems, leaving oceanic systems largely intact. Today, however, oceanic alterations are causing intolerable disruptions to our well-being. Ecological conversion and ecological transition are no longer optional.

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# CO-CREATION BETWEEN INDUSTRY AND RESEARCH FOR A CONNECTED FUTURE

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**Keywords:** energy internet innovation, industry-academia collaboration, smart grid and digital twin technologies, clean energy equipment development, carbon neutrality and policy support

## 1. Introduction

Against the backdrop of a global energy transition, China has been actively advancing an energy revolution. General Secretary Xi Jinping's call for an energy revolution has provided clear direction for the development of the energy sector, with the dual goals of carbon peaking and carbon neutrality becoming key principles guiding industry growth<sup>1</sup>. In 2015, China and the United States signed the "Climate-Smart/Low-Carbon Cities 2+2" cooperation agreement. That same year, the Sichuan Provincial Party Committee and Provincial Government proposed a provincial-university collaboration strategy, under which Tsinghua University became Sichuan's first partner. Leveraging this opportunity, the Sichuan Energy Internet Research Institute of Tsinghua University was officially inaugurated in March 2016 in the Tianfu New Area, Sichuan<sup>2</sup>. The institute carries significant expectations from both the local government and the university, envisioned as a hub for talent, technology, and industrial development, with the mission to elevate Sichuan's and even the nation's energy industry to new heights. As a major province for clean energy, Sichuan boasts the nation's leading reserves of hydropower and natural gas, along with significant advantages in complementary wind, solar, and hydropower resources. This creates a fertile environment for the practical application of the institute's technological achievements.

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<sup>1</sup> LI, ZHAO 2025, 1243.

<sup>2</sup> Introduction to Sichuan Energy Internet Research Institute, Tsinghua University <<https://en.tsinghua-eiri.org/single.aspx?t=5>>.

## 2. Innovation in Key Equipment for the Energy Internet

### 2.1 *Multi-Port Power Router*

With the challenge of high-proportion new energy being connected to the power grid, it is urgent to build the grid's regulation capability. Multi-port power routers have emerged as the times require<sup>3</sup>. Analogous to network routers, they can achieve rapid networking and are applied to AC and DC power grids. Faced with the diversity of power supply characteristics of distributed power sources and load demands, power routers need to support plug-and-play interfaces to quickly identify the types of distributed energy and respond to networking; possess bidirectional interfaces to realize the two-way transmission of energy; and rely on real-time communication to calculate power consumption or upload, thus providing users with efficient power management. They have been recommended as significant achievements of the "13<sup>th</sup> Five-Year Plan" National Key Special Project on Smart Grid.

### 2.2 *DC Circuit Breaker Based on IGCT*

IGCT (Integrated Gate Commutated Thyristor), a high-capacity power semiconductor, belongs to the same category of high-power electronic switching devices as IGBT (Insulated Gate Bipolar Transistor), but with a different structural principle. While international flexible DC converters typically use IGBTs, with related technology patents dominated by Germany and the Netherlands, Tsinghua University has broken through the bottleneck by developing the IGCT-plus<sup>4</sup>. The IGCT-plus combines the advantages of the IGCT, including strong switching capabilities and high current-carrying capacity, and addresses key challenges such as voltage and current rise rates. It holds potential for low cost, high reliability, and high efficiency, reaching an internationally advanced level<sup>5</sup>. It has already been applied in the flexible DC grid for power transmission to the Zhangjiakou competition venues during the Beijing Winter Olympics<sup>6</sup>.

### 2.3 *Hydrogen Fuel Cells and Derivative Equipment*

Hydrogen energy research focuses on "one source, one tail". The source end uses hydropower electrolysis for hydrogen production in Sichuan, while in northern regions, wind and solar

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<sup>3</sup> LV *et al.* 2023, 3651; ZHAO *et al.* 2025, 1243.

<sup>4</sup> ZHANG *et al.* 2019, 1165-1170.

<sup>5</sup> QU *et al.* 2019, 2974-2979.

<sup>6</sup> LI 2020.

power are considered for electrolysis. The tail end involves high-temperature combustion of hydrogen for power generation, with distributed clean energy stations ranging from 5 to 10 megawatts, offering widespread application. The Solid Oxide Fuel Cell (SOFC) team has pioneered ZTSOCTM technology<sup>7</sup>, overcoming bottlenecks related to startup, reliability, and other challenges. This technology eliminates the need for high-temperature alloy connection plates and glass sealing rings, featuring rapid start-up and shutdown capabilities, and demonstrating significant advantages in multiple scenarios.

#### *2.4 New Type of Non-Combustion Compressed Air Energy Storage System*

Large-scale energy storage focuses on pumped hydro storage and compressed air energy storage<sup>8</sup>. The research institute adapts to local conditions, utilizing natural sealed salt caverns for energy storage in areas such as Zigong in Sichuan and Jintan in Jiangsu. In Jintan, Jiangsu, the world's first non-combustion compressed air energy storage power station with a capacity of 60 megawatts has been built, achieving an energy conversion rate exceeding 67%<sup>9</sup>.

### **3. Advanced Smart Energy Systems**

By leveraging big data, artificial intelligence, and blockchain technologies, the goal is to empower the intelligent upgrade of energy systems, focusing on the modeling and simulation of large-scale energy hubs to achieve digital twins (with simulation accuracy exceeding 99%). Tsinghua University's Cloud Simulation team, through its CloudPSS system, stands out with significant advantages. Under the same hardware conditions, the scale of electromagnetic transient simulations for renewable energy stations is expanded by a factor of 10, and the speed is increased by 40 times<sup>10</sup>. This development drives the transformation of energy supply models, optimizing configurations, improving energy efficiency, and promoting clean and low-carbon solutions. It has been applied in several projects, including the Winter Olympics, Shenzhen Power Supply Bureau, and China Shipbuilding Industry Corporation. For example, in the Tianfu New Area Xingle Lake Zhi Shui System, 8,000 sensors installed through government-led initiatives and corporate investments gather data. This data is analyzed by the research institute to provide scientific support for decision-making.

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<sup>7</sup> SINGH *et al.* 2021, 27643-27674.

<sup>8</sup> XU 2019.

<sup>9</sup> YE 2021.

<sup>10</sup> <<https://eea.tsinghua.edu.cn/info/1038/3453.htm>>.

## **4. Information Empowerment Practices**

### *4.1 Situation Awareness Technology*

The self-developed intelligent fittings are used for long-distance transmission networks. These fittings include four mechanical arms that grip the cables, with built-in sensors and chips to collect operational and fault information. A device is installed every 900 meters, and they communicate with each other, transmitting data to the grid control center. This system solves the challenges of manual inspection and has been widely applied and promoted in the high-altitude, cold regions of the Yunnan-Guizhou area in the Southern Power Grid.

### *4.2 Online Monitoring Technology*

Leveraging energy sensing capabilities, the focus is on the development of online monitoring and diagnostic instruments for high-end power equipment, providing customers with precise detection services.

### *4.3 Intelligent Inspection Technology*

In the field of hydropower hubs, the Smart Hydropower and Watershed Safety Research Center has developed an integrated “air, land, and water” intelligent robot inspection system. For example, the tunnel robot, connected via cable between the mother and child machines, addresses the challenges of communication and power supply for operations in complex, water-laden tunnels<sup>11</sup>. The aerial dam inspection drone, in collaboration with DJI, features a self-developed system for inspection, ensuring the operational safety of hundreds of hydropower stations in regions such as Northwestern Sichuan.

## **5. Energy Carbon Neutrality Responsibility**

As a think tank for national and provincial energy bureaus, the research institute participates in energy policy formulation and the exploration of carbon market mechanisms. It has helped establish the first domestic market simulation and trading decision cloud platform for Guangdong Province. The low-carbon strategy research team provides “1 + N” low-carbon policy support to various local governments.

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<sup>11</sup> Li 2021.

The institute places a strong emphasis on the commercialization of scientific research outcomes<sup>12</sup>, with Sichuan Yichong Technology Co., Ltd. being a prime example, with a valuation exceeding 2.5 billion yuan and plans for an IPO on the Sci-Tech Innovation Board. At the same time, intellectual property protection is a priority, with numerous patents and copyrights being applied for, earning several provincial-level intellectual property honors and promoting the transformation of research achievements.

## 6. Conclusion

Since its establishment, the Tsinghua Sichuan Energy Internet Research Institute has closely aligned its work with national energy strategies and regional energy advantages, innovating across multiple fields. Through the development of key equipment, the construction of smart energy systems, the implementation of information empowerment methods, and exploration in the energy carbon neutrality field, the institute has achieved breakthroughs in scientific research and industrial transformation. This dual success provides strong momentum for the high-quality development of China's energy industry and the realization of the carbon peak and carbon neutrality goals. The institute is poised to continue leading the wave of innovation and transformation in the energy sector.

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# BIODIVERSITY AND ECOSYSTEM RESPONSES TO CLIMATE CHANGES AND HUMAN WELL-BEING: RESEARCH PRIORITIES AND CHALLENGES

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**Keywords:** biodiversity-ecosystem functioning nexus, individual-based ecological responses, trait-based adaptation and evolvability, climate-driven functional trait shifts, ecosystem services and human well-being

Earth is a living planet, with a fixed amount of energy supply and a diversity of life forms whose capacity to grow in number is potentially unlimited. Ecological energetics and evolution are the interconnected drivers of the development and maintenance of the diversity of life, both within populations and among species, under an otherwise limiting context. Earth ecosystems have reached equilibrium conditions through processes of adaptation and coadaptation of the life forms along their abiotic niche dimensions and processes of coadaptation and coevolution both within populations and among populations and species.

Climate change, causing a systematic and directional alteration on key abiotic niche dimensions, is resulting in individual level responses with cascading impact on populations, species and communities threatening the current adaptation, coadaptation and coevolutionary equilibrium status of Earth ecosystems. Among individual level responses, those related to the cost of life (expressed as the metabolic costs) and to the overall individual energy budget are likely to have quantifiable metabolic theory-based implications both on other individual functional traits and on the higher levels of the ecological hierarchy. This includes influences on traits, such as individual perception of resource availability and related space use behavior, as well as on density and intensity of inter-individual interactions and competitive performances, species and communities carrying capacities, ecosystem processes and services. This ultimately challenges the benefits that humans derive from ecosystems processes and services.

Individual-based responses have been observed to show heterogeneities both among taxonomic groups and across spatial dimensions (e.g., latitudinal, altitudinal, bathymetrical). However, common patterns seem to arise:

- Ectotherm species, accounting for almost 95% of the overall animal species on Earth<sup>1</sup>, increase their cost of life by 6% to 10% per degree of thermal increase<sup>2</sup>.
- Individual space use behavior and individual home range directly scale with individual cost of life<sup>3</sup> with increasing probability of inter-individual encounters and interactions per degree of thermal increase.
- Net primary productivity (NPP) and net ecosystem productivity scenario show decreasing trends with increasing global warming, with maximum expected loss by 2100 in European river basins exceeding the 20,0%<sup>4</sup> - though this could even be an underestimation of NPP losses<sup>5</sup>, due to a potential bias in current models.
- Soil carbon scenarios suggest a net carbon release at the global scale by 2050, accounting for 13% to 17% of expected carbon emissions during the same period<sup>6</sup>.
- The average individual body size of marine species shows a 3,5% decrease per degree of thermal increase on a latitudinal gradient<sup>7</sup>.
- Unless mechanistic mitigation and adaptation strategies are designed and put in force now, future ecosystems seem likely to be characterized by decreasing organic biomass, with decreasing population densities or individual body size, reduced biodiversity and capacity to support our social and economic growth.

Deeper knowledge and lower uncertainty on the quantitative responses of biodiversity and ecosystems to climate change are crucial to design effective actions and strategies to lessen their negative impacts on our social and economic growth. Deeper knowledge is also needed on the competitive interactions among phenotypes characterized by different individual personalities<sup>8</sup> occurring within populations. Changes in how these phenotypes perform relative to one another would have an impact on phenotype arrangements both within populations and among populations and species either magnifying or mitigating the negative implications of biodiversity and ecosystem responses to climate change at the higher levels of the ecological hierarchy. A conceptual framework has been built on the patterns of inter-phenotypic differences in the individual niche breadth, on the underlying mechanisms and on the key selective pressures favoring the specialist and the generalist

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<sup>1</sup> BAR-ON *et al.* 2018, 115.

<sup>2</sup> SHOKRI, LEZZI, BASSET 2024, 124.

<sup>3</sup> SHOKRI, COZZOLI, BASSET 2025.

<sup>4</sup> SONG *et al.* 2018, 415-420.

<sup>5</sup> RYAN-KEOGH, TAGLIABUE, TOMALLA 2025, 75.

<sup>6</sup> CROWTHER *et al.* 2016, 104-108.

<sup>7</sup> FORSTER, HIRST, ATKINSON 2012, 19310-19314.

<sup>8</sup> BIRO, STAMPS 2008.

components of populations<sup>9</sup>, respectively. The covariation of other individual functional traits with individual niche breadth along with an individual niche breadth-based trade-off between rate and efficiency of resource exploitation, as a mechanism allowing intra-population maintenance of phenotypic diversity, have some experimental evidence<sup>10</sup>. This evidence would suggest that changes in the phenotype arrangements in response to decreasing resource availability, as is expected to occur in future ecosystems, could potentially mitigate the influence of the ecological responses to climate change on our well-being.

Despite an increasing body of research addressing biodiversity and ecosystem responses to climate change as well as individual and population level plasticity, evolvability and adaptability, the uncertainty in the scaling of these responses to climate change from the individual to the population and up to ecosystem levels remains high<sup>11</sup>. The available data are still limited, as well as the current knowledge on species trait phenotypic responses to changing intra and interspecific interactions and competition on limiting dimensions.

To address the global challenges posed by climate change, there is an urgent need to boost scientific research on biodiversity and ecosystem responses and on their impact on our societal well-being. This is foundational to reduce uncertainty in the assessments and to provide a solid ground for developing strategies of mitigation and adaptation addressing the biodiversity and ecosystem mediated impacts of climate change, - which are still almost lacking.

The European Research Infrastructures (ERIs) are the European response to boost the excellence of scientific research in Europe, enhancing its competitiveness at the global scale. Italy participates in most of the ERIs instituted by the European Commission over the past 10-15 years and has funded a project, ITINERIS, which integrates 22 RIs, mostly from the Environmental domain, representing a model of collaboration and synergy among RIs at the continental scale. The main objectives of ITINERIS are:

- Deepening knowledge in the environmental domain on both abiotic and biotic components, on the processes underlying their organization, functioning and service providing, filling in the gaps in the available data.
- Giving physical (e.g., ICOS, eLTER, SIOS, Danubius-RI) and/or virtual (e.g. LifeWatch) access to integrated services of the different RIs on key scientific priority issues and challenges.
- Developing advanced services to ensure the Findability, Accessibility, Interoperability and Re-usability (i.e., FAIRness) of both data and all other digital objects resulting in

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<sup>9</sup> ROUGHGARDEN 1972, 683-718; GLASSER 1982, 250-262; GARRIDO DE LEON, FRANCO-TRECU, COSTA-PEREIRA 2025.

<sup>10</sup> BASSET, ROSSI 1987, 13-18.

<sup>11</sup> STARK *et al.* 2025, 3.

scientific research products (from models to virtual research environments, training and communication materials).

- Extending the data and service integration to the main national/regional research and environmental monitoring Centres, which are not directly involved in ITINERIS.

As regards more directly the biodiversity and ecosystem responses to climate change, LifeWatch ERIC, the only European eScience Infrastructure on Biodiversity and Ecosystem Research, has a well-identified and central role. LifeWatch ERIC is deeply rooted in the biodiversity and ecosystem research community and has established collaborations with other ERIs with complementary interests and fields of competence. Taking advantage of these collaborations, LifeWatch ERIC co-designs and co-develops both the theoretical and conceptual framework to address biodiversity organization, functioning and service delivery within ecosystems, and the ICT services required to run the data analysis and modelling in Virtual Labs (VLs), Virtual Research Environments (VREs), up to advanced Digital Twins (DTWs). Biodiversity and ecosystem responses to climate change is one of the priority *thematic services working groups* of LifeWatch ERIC, which operates based on a bottom-up process of co-design and co-development of VREs with research groups or even single researchers, including early career ones, to test breaking-the-mold hypotheses and to run data intense projects.

The engagement of the research community and the collaboration with other ERIs and relevant Initiatives, as in the project ITINERIS, are the keys to speed the process of deepening knowledge and understanding on climate change-mediated responses of biodiversity and ecosystems. It is the required step also to promote and support the development of mitigation and adaptation strategies matching the conservation of biodiversity, ecosystem functioning and services with the societal needs of a sustainable world-wide development.

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## **FORUM 4**

### **Disaster Risk Reduction**



## THE ITALIAN EARLY WARNING SYSTEM FOR METEO-HYDRO RISKS

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**Keywords:** early warning system, functional centers network, meteorological and hydrological forecasting, real-time monitoring and surveillance, criticality and vigilance bulletins

The Italian Early Warning System for Meteorological, Hydraulic and Hydrogeological Risks is based on the network of functional centers which consist of the Central Functional Center, located at the Italian Department of Civil Protection in Rome, and decentralized functional centers located in each Italian region and autonomous provinces. Each functional center focuses on forecasting, monitoring and surveillance activities of weather phenomena in real time with the resulting assessment of the expected effects on people and things in each territory.

This system was designed at state level in 2004 provided for by the Directive of 27 February 2004 that sets out the “Operational guidelines for the organizational and functional management of the national, state and regional warning system for hydrogeological and hydraulic risk for the purposes of civil protection”. It was also implemented across the Regions through their respective contributions in the following years.

The Central Functional Center is located at the operational headquarters of the Department of Civil Protection in Rome<sup>1</sup>, it is operational 24/7, and, together with the Regions, ensures the coordination of the national warning system. In addition, consistent with the principle of subsidiarity, in cases where the decentralized functional centers are not active or are temporarily not operational, the Central Functional Center performs all operational tasks assigned to it.

The Functional Center network performs both forecasting, monitoring and surveillance activities of meteo-hydrogeological and hydraulic events and their impact on the territory in order to define risk scenarios, or to assess the impact that these events could have on the integrity of life, property, settlements and environment.

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<sup>1</sup> [www.protezionecivile.gov.it](http://www.protezionecivile.gov.it)

## 1. Forecasting Activities

According to state legislation, every day, by 12.00 noon, under the coordination of the Department, a technical group for meteorological forecasts contributes to the elaboration of the official National Weather forecasts for the civil protection system at synoptic scale, to be transmitted to the National Service of Civil Protection. This group includes the Central Functional Center, the Meteorological Service of the Air Force and the Decentralized Functional Centers of the Regional Agency for Environmental Protection of Piedmont and Emilia Romagna.

Moreover, the Central Functional Center issues to the National Service of Civil Protection a Bulletin of National Meteorological Vigilance. This is a document that reports the situations in which one or more meteorological parameters are expected to exceed certain thresholds of attention or alarm, for the day of issue and for the following 48 and 72 hours<sup>2</sup>.

When the events affect two or more regions, the Central Functional Center, once acknowledged the assessments of the Decentralized Functional Centers, can issue a national weather warning (warning of adverse weather conditions) for the National Service of Civil Protection. The issuance of a warning is also announced through press releases.

Each Functional Center performs an assessment of the possible occurrence, or evolution, of effects on the ground (landslides and floods) as a result of expected or ongoing weather events. These evaluations are concerted and collected by the hydrogeological and hydraulic division of the Central Functional Center in the criticality Bulletin released every day, published and shared to the operational structures of the national civil protection system<sup>3</sup>.

## 2. Monitoring And Surveillance Activities

During the monitoring and surveillance phase, the Central Functional Center collects data from meteorological satellites, the national radar network and the network of ground stations to ensure continuous control of weather and hydrological phenomena and to follow the course of events throughout the territory, together with the decentralized functional centers. At this stage it is fundamental to receive information from the territorial units: structures responsible for observing, monitoring and supervising the phenomena and their

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<sup>2</sup> The document is published every day at 3 p.m. on this website: <https://mappe.protezionecivile.gov.it/it/mappe-rischi/bollettino-di-vigilanza>

<sup>3</sup> The National Criticality Bulletin is available on this website: <https://mappe.protezionecivile.gov.it/it/mappe-rischi/bollettino-di-criticita/>

evolution on the territory. The information and data collected allow the Central Functional Center to keep constantly updated the Situation Room called “Sala Situazione Italia” and monitoring of the territory called “Sistema”.

The main monitoring and surveillance tools are the national radar network and the network of meteo-hydropluviometric stations. The former can estimate the presence and intensity of precipitation in the atmosphere almost in real time, and observe the movement of disturbances, while the latter can measure precipitation falling on the ground and river level variation.

Other data and information are collected from satellite platforms such as EUMETSAT for Earth observation (e.g., soil moisture data).

Based on these data, the Functional Centres elaborate the probabilistically expected scenarios, also using forecasting models of the effects on the territory. Based on these evaluations, the Regional Functional Centres issue bulletins and warnings in which both the evolution of the phenomena and the expected criticality levels on the territory are reported.

## *2.2 The meteo-hydropluviometric stations network*

The meteo-hydropluviometric stations are telemetry stations. They consist of instruments that measure weather conditions and send data in real time. The stations feature several sensors, which transmit the measured data to the regional collection and processing centers in real time. As of early 2012, these stations numbered more than 4,500 and include 2,000 rain gauges (to measure the amount of rain), 1,130 hydrometers (to monitor river levels) and 3,500 sensors like thermometers (to measure temperature), anemometers (to measure wind intensity) and snow gauges (to measure snowfall).

In the last years the regional owned stations have been upgraded thanks to the application of some civil protection ordinances aimed at improving the observation and monitoring capacity of phenomena and at optimizing the use of data, in real time, for civil protection purposes.

## *2.3 Data sampling*

The meteo-hydropluviometric stations have a data sampling time (the interval between consecutive measurements) that varies between one minute and one hour and a “latency time” generally of 30 minutes, that is the time between the measurement and the effective availability of data to the operator.

#### 2.4 *Data transmission and processing*

The measurements collected are transmitted via radio or GSM/GPRS systems to the monitoring center of each functional center that displays, processes and shares them through the Civil Protection network, assuring information sharing between functional centers. The data elaborated are sent in “packets” to the server of the Department. In order to compare, integrate and synthesize the data necessary for the real-time evaluation of the meteorological situation, a further dedicated platform has been designed and is continuously improved: the Dewetra system.

#### 2.5 *The Dewetra web-based platform*

Dewetra is an integrated system for real-time monitoring and natural risks prevision and prevention. The system provides the necessary synthesis, integration and comparison for tool monitoring, risk scenarios vigilance and evaluation and possible evolutions. The project was designed thanks to an agreement between the Civil Protection Department and CIMA Foundation - International Centre for Environmental Monitoring and operates at the Civil Protection Department.

Dewetra uses hybrid architecture which combines an integrated server for the back-up of data collected locally and web applications that allow a capillary distribution of the information. The software provides a graphical interface displaying continuously updated high-resolution data, allowing the user to track weather events, build detailed risk scenarios and evaluate phenomena potential impact on communities and infrastructures.

Dewetra allows any computer connected to internet to use, in geographic modality, the system data independently from the source. In fact, the software manages both the data used by the platform of Functional Centre National System and the territorial and geospatial ones, published as WMS service - Web Map Service- by other platforms. Dewetra is able to upload and visualize geo-referenced layers both static and dynamic, allows to view results of each measurement station and other observation tools more advances and offers interactive tools and features for users to analyze ongoing or past events.

#### 2.6 *The meteorological radar network*

The project of the radar network on a national scale, developed and managed by the Department of Civil Protection, aims to ensure a better monitoring capacity of atmospheric phenomena on a national scale by integrating radar observations both with satellite observations, which provide information on cloud, and with rainfall sensors, which record data accurately at ground level, usually not highly representative of an entire catchment area. The implementation of an

operational system of interconnection and fusion of meteorological radar data in real time implies the definition of a mosaic process. The need to implement this network arises both from the necessity for large-scale meteorological monitoring and from the need to improve the quality of the measurements of single radars. In fact, the use of a single radar involves a series of problems that limit its effectiveness. These problems are due to technical-instrumental anomalies (e.g. calibration, interference from W-LAN networks), the orographic complexity of the territory and the physical characteristics of the meteorological phenomenon observed.

The network is being completed and includes fixed and mobile radars, distributed throughout the country. Currently, the National Radar Network consists of 26 operational radars of which 12 are installed and managed directly by the various regions, 1 owned by the Air Force and 2 by ENAV, and 11 (7 C-Band Radar and 4 Mobile Radar in X-Band) were installed by the DPC and are operational around the clock to ensure an effective monitoring of various weather phenomena throughout the country.

Radar-DPC is the platform of the Civil Protection Department that allows to see on a national scale both ongoing phenomena and phenomena recorded within 24 hours through the processing in real time of raw data from the national radar network, rain and temperature stations networks, satellite data and lightning network<sup>4</sup>.

The architecture of the whole system foresees that at the Central Functional Center are collected the data made available by all agencies and administrations that contribute to the national radar network. The Central Functional Center generates different products in order to guarantee the best possible coverage, then distributes the data in real time to the Decentralized Functional Centers (CFD) and to the national Institutional Bodies with a frequency of fifteen minutes through different platforms. Each CFD, in full autonomy and under its own responsibility, defines the operational use of these products through any necessary procedures.

The weather radar is an instrument used to:

- monitor precipitation phenomena in real time, identifying their intensity and physical state (rain, snow, hail), through the study of polarization characteristics;
- estimate the precipitation over large geographical areas, providing information complementary and integrable with those derived from the conventional ground monitoring network, in order to provide a more accurate reconstruction of precipitation;
- to estimate in real time intensity and average direction of movement of a bad weather event;
- follow the evolution of bad weather event;
- to make precipitation estimates more accurate by integrating radar network data with ground monitoring data and satellite observations.

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<sup>4</sup> The platform is available on the web site: <https://mappe.protezionecivile.gov.it/en/risks-maps-and-dashboards/radar-map/>



# **SINO-ITALIAN COOPERATION ON HAZARD MITIGATION: RESPONSE TO CLIMATE CHANGE SINO-ITALIAN JOINT LABORATORY ON GEOLOGICAL AND HYDROLOGICAL HAZARDS**

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**Keywords:** sino-italian scientific cooperation, geological and hydrological hazards, mountain risk mitigation, climate change adaptation, early warning and monitoring systems

## **1. Introduction**

As a part of 13<sup>th</sup> Sino-Italian Innovation Cooperation Week, the topic of this presentation is the Sino-Italian Cooperation on Hazard Mitigation in Response to Climate Change. We would like to share the cooperation experience between the IMHE-CAS and IRPI-CNR in the development of Sino-Italian Joint Laboratory on Geological and Hydrological Hazards. And through this forum we hope to deepen international scientific and technological cooperation and contribute to addressing the challenge of global climate change.

This report mainly covers the following aspects. The first part is the background and significance of Sino-Italian cooperation, expounding its strategic necessity for China and Italy. The second part is the common challenge in hazard mitigation faced by both sides. Then the third part briefly summarizes the cooperation works of the joint laboratory, and their research accomplishments and practical applications. Finally, the future cooperation plans to further strengthen the cooperative relationship between China and Italy.

## **2. Strategic Importance and Background of Sino-Italian Cooperation**

First, mountain hazards pose a significant impact on both China and Italy. Both of our countries are mountainous countries with active geological structures, with widely distributed and frequently occurring mountain hazards such as landslides, debris flows and flash floods. Meantime, both countries have large populations living in areas exposed to high risks, and thus hazard mitigation is equally crucial to those people.

Secondly, mountain regions have been highly sensitive to climate change which has become more intense in recent years and has made mountain hazards more threatening

in Asia and Europe. Global warming results in higher occurrence of extreme heat and precipitation events, leading to intensified degrees of drought and flood, glaciers melting, permafrost recedes, snow coverage and duration decreases, and thus small-probability and large-scale extreme events are easier to appear, giving bigger challenges to the traditional hazard mitigation methods<sup>1</sup>.

The key to the common challenge faced by China and Italy is to control the risks in mountain regions under climate change. Currently, our understanding of the dynamics and mechanisms of hazard chains remains insufficient, and the available methods of quantitative risk analysis and resilience management are inadequate. Therefore, there is a lack of scientific and effective risk management techniques for mountain hazards based on dynamic analysis. Such a situation requires more systematic research and more efficient international cooperation.

To address these challenges, China and Italy have launched the Sino-Italian Joint Laboratory on Geological and Hydrological Hazards in 2013, which is a crucial platform for bilateral cooperation on the science and technology of hazard mitigation. The laboratory integrates research advantages of the Chinese party, IMHE-CAS, in hazard dynamics and risk assessment with technical expertise of the Italian party, IPRI-CNR, in monitoring, early warning and risk management. Through our joint work on the contrast research between Qinghai-Tibet plateau and the Alps, both parties have been exploring new mitigation modes for mountain hazards and new coping approaches to climate change.

Through the effort of both Chinese and Italian parties under the leadership of Academician Cui Peng and Professor Alessandro Pasuto, Sino-Italian Joint Laboratory has obtained internationally leading achievements in several research aspects, including quantity of published papers, theoretical innovation, and techniques of risk analysis, management, prevention and control.

Since the establishment of the Joint Laboratory, we have continuously been collaborating under the international cooperation projects approved by either China or Italy, showing that both countries attach great importance to the close collaboration between IMHE and IRPI.

### **3. Representative scientific research achievements produced by the work of Sino-Italian Joint Laboratory on Geological and Hydrological Hazards**

- The altitude differences in warming and humidification in Alps and HMA and the resultant irregularity in the melting pattern of ice and snow. We have reported that high-

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<sup>1</sup> KNIGHT 2022.

altitude mountain areas show more pronounced warming and humidification than low-altitude areas and that Alps gives higher warming rates but HMA's snow cover shows higher sensitivity to temperature<sup>2, 3</sup>.

- Evolution mechanism under tectonic action of the entire process from fracture expansion to the high-speed landslide motion. We combined field observation and numerical simulation to find out that source area is formed by tensile fractures generated by tectonic movement, landslide leads to the free face deformation of the unstable body, shoveling affects landslide mobility and volume, and topographic humps can cause grain size differentiation of the deposit body<sup>4, 5</sup>.
- The development of the first debris-flow numerical simulation platform in the world which can solve the entire process of the rainfall-induced initiation, downslope motion, deposition and potential regulation of debris flows. Our platform is of powerful functions including scenario analysis, risk prediction, engineering optimization, and efficacy evaluation; moreover, contrasted with other similar software, this platform holds advantages of large scale (simulation range of thousands of km<sup>2</sup>), high resolution (mesh in meters) and high efficiency (up to 30 minutes simulation time for a landslide or debris flow with volumes of millions of m<sup>3</sup>), pulling more than a thousand users from professionals around the worlds.
- Establishment of mountain hazard monitoring and early warning system in the earthquake region in Sichuan, China. We introduced an advanced landslide and debris-flow monitoring technique from IRPI-CNR and combined multiple functions such as data monitoring, real-time feedback, hazard trend analysis, and hazard warning into an integrated system. With the application of our monitoring and early warning system, the generation and confluence process of flash flood and debris flows can be analyzed, as well as their movement and evolution process.
- The technological system for mountain hazard prevention and control. We have developed a system combining the techniques of hazard identification, monitoring, early warning, and community resilience evaluation. From 2015 to 2020, our system has released public warning broadcasts 10 times and has notably improved the timeliness and accuracy of information reporting<sup>6</sup>.
- Multi-agent collaborative community hazard risks management. This risk management model we designed for communities in mountainous areas utilizes the participation of

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<sup>2</sup> PEPIN *et al.* 2022.

<sup>3</sup> BLAU *et al.* 2024.

<sup>4</sup> HU *et al.* 2018.

<sup>5</sup> ZHOU *et al.* 2018.

<sup>6</sup> INTRIERI *et al.* 2018.

community administrators, residents, experts and scholars, and thence promotes the construction of demonstration communities for autonomous hazard management in China.

#### **4. Conclusion**

The Sino-Italian Joint Laboratory on Geological and Hydrological Hazards has gained achievements in and contributions to both theories and techniques of hazard mitigation. We managed to push the hazard evolution mechanism from concentrating on individual processes for a certain type of hazard to the quantitative description on multi-field dynamics for complex multi-phase media. We also made a breakthrough in sensing and monitoring techniques for the entire process of mountain hazard, by extending the forecast time from short-to-medium-term of megascale hazard to long-term season-crossing, and by increasing the early warning accuracy from 60-70% to more than 90%.

For all those achievements we have accomplished through the cooperation with IRPI-CNR, Professor Alessandro Pasuto, the Italian director of our joint lab, has been granted the 2023 Sichuan Tianfu Friendship Award by Chinese government of Sichuan Province, for his efforts in promoting the China-Europe technological cooperation and the contribution of the joint lab to the hazard mitigation work in Sichuan Province.

The next steps in China-Italy cooperation are designed surrounding the Sino-Italian Joint Laboratory on Geological and Hydrological Hazards to support the overall goals to explore a multi-channel and efficient China-Europe multilateral international cooperation pattern for hazard mitigation, and to establish a research platform on hazard mitigation with international influence. Main tasks on the next stage will include: (1) providing a professional international cooperation platform to hazard mitigation specialists; (2) grooming a high-level international research team; (3) increasing the international influence of China-Europe research and serving the need for hazard mitigation for international societies; (4) supporting the UN program on hazard mitigation by carrying out research on hazard mitigation in high mountain areas under climate change. We are also planning to apply more fundings to attract more international students and visiting scholars, to perform a series of short-term training courses to produce more professionals.

Our medium-term goals include further research on hazard mechanisms (on formation, evolution and effects), monitoring methods, control techniques and risk analysis and management. In a long term, we aim to build up a top-tier research center on hydrogeological disasters for the development of relevant disciplines and the growth of young scientists in both China and Italy.

These goals cannot be achieved without a strong research team. Our joint lab gathered 57 members of four professional fields, i.e. hazard dynamics, monitoring, mitigation

techniques, and risk management, in which 22 members are from the Italian party, IRPI-CNR, and 35 are from the Chinese party, IMHE-CAS.

We expect to fulfill a new research paradigm consisting of theoretical studies, technical application and social demonstration. Through the execution of our plans, we will be seeking more technical breakthroughs, strengthening our team, applying our research output to the Tibet Plateau and Alps, and obtaining more intellectual properties including publications and patents.

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# GEOLOGICAL EFFECTS INDUCED BY RECENT EARTHQUAKES IN ITALY AND CHINA: INPUTS FOR IMPROVED SEISMIC INTENSITY ASSESSMENT

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**Keywords:** earthquake environmental effects, ESI 2007 scale, surface faulting, seismically induced landslides, seismic intensity assessment

## Introduction

Earthquakes affect people, buildings, and the natural environment. The latter, referred to as Earthquake Environmental Effects (EEEs), are commonly divided into two main categories:

- Primary effects, directly linked to the earthquake source (seismogenic fault), such as surface faulting, regional uplift, and subsidence;
- Secondary effects, induced by coseismic ground shaking, such as landslides, liquefactions, soil compaction and ground settlements.

To assess seismic intensity based solely on environmental effects, the ESI 2007 intensity scale<sup>1</sup> was developed. This scale provides an intensity assessment based on the classification of EEEs in 12 degrees, that were estimated through the characteristics and areal extent of primary and secondary effects. The ESI scale is particularly effective for seismic intensities > IX-X degree, when damage-based assessments become challenging and only environmental effects remain diagnostic. It is also applicable in sparsely populated areas where structural effects are rare, and environmental effects are the only diagnostic features available. The ESI scale has been successfully applied to many recent and historical earthquakes with reliable and representative EEE data<sup>2</sup>.

This study was conducted as part of a bilateral cooperation project between ISPRA's Italian Geological Survey Department and the Chinese Geological Survey, particularly the Chengdu Center in Sichuan. The project aimed to compare the geological effects of six

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<sup>1</sup> MICHETTI *et al.*, 2007; SERVA *et al.*, 2016.

<sup>2</sup> GUERRIERI *et al.*, 2015 for a review.

moderate-to-strong earthquakes recently occurred in Sichuan (China) and Central Apennines (Italy). Specifically, it examined the applicability and effectiveness of the ESI intensity scale in regions characterized by rather different tectonic settings (compressive and strike-slip vs. extensional), and by different local conditions (e.g. geomorphologic, lithologic and climatic) that may have influenced the occurrence and size of individual EEEs at a specific site. Preliminary results of this study have been published in Ni *et al.*<sup>3</sup>.

### **1. EEEs induced by recent earthquakes in Western Sichuan (SW China)**

Western Sichuan is a steep mountainous region located in SW China characterized by three main active fault zones with reverse and strike-slip movements: i) Longmenshan Fault; ii) Xianshuihe Fault and iii) Anlinghe Fault. Numerous strong historical earthquakes have occurred along these fault zones, such as the Mianning earthquake of 1536 (Ms 7.5) and the Xichang earthquake of 1850 (Ms 7.5) along the Anlinghe Fault zone.

On May 12, 2008, a Mw 7.9 earthquake struck Sichuan, with an epicentre near Wenchuan, causing nearly 90,000 fatalities, 375,000 injuries, 15 million homeless, and significant infrastructure damage.

Surface rupture associated with this event was significant, extending for 220-240 km along the Longmenshan thrust, with maximum recorded displacements equal to 6.2 m in vertical and 4.9 m in horizontal. Approximately 196,000 seismically induced landslides were observed over a 50,000 km<sup>2</sup> area. Some large landslides mobilized over 10 million cubic meters of material, blocking rivers and forming ephemeral lakes. Based on the extent of surface faulting and the total area of secondary effects, the epicentral intensity ESI reached the maximum value on the ESI scale (XII).

On April 20, 2013, a Mw 6.6 earthquake struck Lushan, 130 km west of Chengdu, causing over 200 deaths and 11,000 injuries. The responsible fault was the Shuangshi–Dachuan Fault, part of the Longmenshan thrust system. No evidence of surface faulting was found, but nearly 4,000 slope movements occurred, mostly rockfalls and shallow slides. It was clearly observed that slope movements were much smaller and frequent than those triggered by the 2008 Wenchuan earthquake.

The ESI epicentral intensity equal to X, based on the total extent of the area affected by landslides (5,200 km<sup>2</sup>), with a maximum local ESI intensity recorded in Baoxing County, 40 km from the epicenter, where a giant landslide displaced 180 million m<sup>3</sup> of material. Comparing the local intensity distributions based on geological effects (ESI) and

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<sup>3</sup> Ni *et al.*, 2019.

traditional damage-based assessments reveals comparable scenarios, with a NW bulge in the ESI intensities caused by the abovementioned landslide.

On August 8, 2017, a Mw 6.3 earthquake struck Jiuzhaigou County in Sichuan, causing 20 deaths, over 400 injuries, and displacing 23,000 people. The earthquake occurred along an unmapped fault located among well-documented faults, but no surface faulting was documented. About 4,500 landslides were triggered over nearly 1,000 km<sup>2</sup>, mostly small-to-medium-sized, oriented NW-SE along main valleys. Epicentral intensity ESI equal to IX was based on the total area of secondary effects, consistent with damage-based intensity assessments.

## **2. Earthquake Environmental Effects in Central Apennines (Italy)**

The Apennines' current tectonic structure results from a compressive tectonic phase with NE-oriented thrusts during the Upper Miocene to Lower Pliocene, followed by NE-SW crustal extension from the Upper Pliocene to the Quaternary, still active in present time.

Seismic hazard maps based on historical and paleoseismic data identify maximum magnitudes slightly above 7 in the inner Central-Southern Apennines, controlled by active normal faults trending NW-SE.

On April 6, 2009, a Mw 6.3 earthquake affected Central Apennines with epicentre near L'Aquila. Main damage was concentrated in L'Aquila's historic centre and nearby villages, causing 308 deaths.

Clear surface faulting was observed along the Paganica Fault (~3 km) with displacements not larger than 20 cm. Numerous secondary effects, including rockfalls, ground deformations, and fissures, were mapped over a 2,100 km<sup>2</sup> area. Consistently with the extent of surface faulting and total area with secondary effects and surface rupture extent, ESI epicentral intensity equal to IX was assessed.

On August 24, 2016, a Mw 6.0 earthquake struck Central Italy near the Lazio-Marche-Abruzzo-Umbria border. Surface faulting extended at least 4.5 km along the Monte Vettore Fault, with a maximum vertical displacement equal to 25 cm. Secondary effects were mapped over a 2,700 km<sup>2</sup> area, primarily rockfalls. The resulting ESI epicentral intensity degree was equal to IX, but it was likely underestimated due to the incompleteness of collected data prior to the mainshock.

In fact, on October 30, 2016, a Mw 6.5 earthquake struck the same region near Norcia, due to the reactivation of the entire Vettore-Monte Bove fault system, producing continuous surface ruptures over 28 km and maximum displacements of ~2 m. Over 1,000 secondary effects (rockfalls, landslides, fractures, hydrological anomalies) were documented across ~3,900 km<sup>2</sup>. ESI Epicentral intensity equal to X was estimated, consistently with surface rupture extent and total area of secondary effects, in line with EEE scenarios for Mw 6.5 extensional events.

### 3. Interpretation and conclusions

For all six events, the distribution and size of Earthquake Environmental Effects were proportional to earthquake magnitude, despite differing local site conditions. Only in the case of 2008 Wenchuan earthquake, the extent of surface faulting and a very large area affected by seismically-induced landslides have indicated the highest ESI intensity value (XII), in line with the observed magnitude.

Instead, for moderate earthquakes ( $M_w$  between 6 and 7), surface faulting was observed only in the extensional Apennines, while no such evidence was found for reverse and strike-slip faults in Sichuan. At this magnitude level, local conditions (e.g., lithology, elevation, slope, land cover, climate) should have significantly influenced the occurrence of secondary effects like landslides, as clearly indicated by the 2013 Lushan earthquake. In the Apennine events, a difference of 0.5 in  $M_w$  (from 6.0 to 6.5) has induced a difference of one degree of intensity in the ESI scale (from IX to X).

In conclusion, the comparison of ESI epicentral and local intensities based on surface faulting extent and secondary effects areas with corresponding damage-based intensities confirmed the ESI scale's effectiveness in identifying high-risk areas, especially those more susceptible to the occurrence of landslides and liquefaction. Moreover, this study has provided substantial insights for a revision of the description of ESI intensity degrees in compressive tectonic contexts.

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# STATE KEY LABORATORY OF MOUNTAIN HAZARDS AND ENGINEERING SAFETY, CAS HAS ACHIEVED SIGNIFICANT RESULTS IN DISASTER RISK REDUCTION

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**Keywords:** mountain disaster risk reduction, chain-induced hazards, simulation and early warning systems, engineering safety in mountainous regions, dynamic hazard modeling

The Laboratory of Mountain Hazards and Engineering Safety (hereinafter referred to as the laboratory) is one of the national key laboratories to be established by the Chinese Academy of Sciences. The core scientific issue to be addressed is understanding the mechanisms behind disasters and developing strategies for preventing and controlling chain-induced events in mountainous areas. The main technical objectives are advance identification and accurate early warning of disaster data, simulation and chain-breaking technology for catastrophic and complex chain-induced disasters, precision risk control and emergency disaster reduction equipment, and solutions for major engineering safety protection systems. The primary research subjects include collapses, landslides, debris flows, floods, barrier lakes, and complex chain-induced disasters involving multiple types of disasters.

In the past decade, the laboratory has taken the lead in implementing major scientific research tasks such as the secondary disasters of the Wenchuan earthquake, mountain disasters along highways and railways, disaster reduction for the “Belt and Road” initiative, and disaster reduction on the Tibetan Plateau, leading the field domestically. It has also taken the lead in editing and compiling 8 standards and specifications, including the “Specification of Design for Debris Flow Prevention” guiding disaster prevention and control efforts nationwide.

**Contribution 1:** The laboratory has established a research methodology system for mountain disasters, including in-situ observation, mathematical analysis, physical simulation, and numerical simulation; Revealed the formation, movement, and evolution laws of mountain disasters, establishing the theoretical foundation of the discipline; Constructed a technical system of risk assessment, monitoring and early warning, comprehensive prevention and control, and emergency disaster reduction, founding and leading the development of the scientific discipline of mountain hazard studies.

**Contribution 2:** Overcame critical challenges in the dynamics and process simulation of mountain disasters, developed a full-process simulation platform for “formation-movement-disaster causation” to enable full-scenario simulations and risk assessment of the whole process of disasters. The system has been used in more than 70 universities such as Tsinghua University, the Emergency Management Department, the Ministry of Natural Resources, and various industry enterprises.

**Contribution 3:** Developed a multi-scale risk assessment technology system for mountain disasters based on the dynamic process, which covers “region-corridor-disaster point”. This system provides comprehensive services for disaster reduction planning, regional development, and engineering disaster prevention design in important economic and transportation corridors.

**Contribution 4:** The first “Mountain Disaster Risk Simulation and Hazard Forecasting System Platform” in China has been developed, which has achieved a breakthrough from the regional level forecast of disaster risk to the hazards forecast of disaster point and created a precedent for the mountain disaster model forecast. The system platform has been promoted and applied in western provinces of China.

**Contribution 5:** Developed an active disaster reduction technology system for the entire process of disaster evolution, achieving “precise control of catastrophic disasters,” and doubling the scale of disaster prevention and control; proposed an integrated model balancing disaster reduction with green development, optimizing the disaster prevention and control models for hydropower projects, mountain towns, scenic areas, and supporting mountain area development and engineering safety.

In terms of international disaster reduction, the laboratory has rapidly responded, scientifically assessed, and provided emergency response management for disasters such as the 1999 Venezuela mudslide, the 2010 Pakistan landslide and barrier lake, and the 2015 Nepal earthquake, providing Chinese solutions to affected countries and earning a good international reputation. It has established an international cooperation system of “overseas institutions - scientific programs - academic organizations - international forums” to carry out comprehensive international disaster reduction cooperation.

The laboratory boasts internationally leading large-scale dynamic simulation experimental platforms for mountain disasters, comprehensive experimental simulation platforms for disaster chains, and domestically leading crustal deformation simulation devices and experimental simulation platforms. These can address the challenges of size effects and similarity in the physical simulation of the entire disaster process, making them irreplaceable tools for mountain disaster research both at home and abroad. The “field observation station + experimental analysis equipment + disaster data platform” model provides systematic support for the laboratory’s scientific research. Among them, the Dongchuan Debris Flow Observation and Research Station is the best debris flow research

base in the world in terms of observation conditions and prototype representativeness, offering the longest sequence and the most comprehensive and continuous dataset of debris flow observations. The laboratory's more than 80 sets of large-scale professional instruments and equipment, along with a comprehensive collection of mountain science data, will systematically support the laboratory's scientific research efforts.



# RESEARCH ON REFINED INVESTIGATION AND RISK PREVENTION MANAGEMENT OF GEOLOGICAL HAZARDS IN ALPINE VALLEYS REGION OF SOUTHWEST SICHUAN, CHINA

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**Keywords:** steep mountainous, geological hazards, refined investigation, real-scene 3D

## 1. Introduction

Sichuan is a typical geological disaster-prone area in China, located southwestern China. The geological condition in Sichuan is complex, and mountainous areas account for a large proportion, which leads to an increased occurrence of geological disasters. Landslides, debris flow, collapses and other geological disasters occur from time to time. In recent years, the Sichuan provincial government attaches great importance to the prevention and control of geological disasters, with the utilization of adaptable and advanced technologies like monitoring, early warning, emergency disposal and prevention, the geological disasters prevention and control ability have been improved obviously. Accordingly, the level of public safety have been significantly improved. However, there are still many challenges in geological disaster prevention and reduction.

## 2. Front line of national and local disaster management in China

The state, province, and local government take responsibility for geological disasters management. A series of regulations, standards, and policies have been issued to support the prevention and control of geological disasters.

Policy and regulatory system construction. The “Regulations on the Prevention and Control of Geological Disasters,” which clearly define the principles, responsibilities, and measures for the prevention and control of geological disasters.

Geological disaster control project and residents’ relocation for disaster avoidance. For geological disasters with high risk and relatively large threats, the state has organized and implemented geological disaster control projects. Such as anti-slide piles, retaining walls, slope protection, drainage works, etc., which have effectively improved the stability

of geological disaster bodies and reduced the risk of disasters. However, the relocation of residents for disaster avoidance is the ultimate solution.

Scientific and technological support and innovative development. The investment in scientific research and development for the prevention and control of geological disasters has increased, and scientific research institutions and universities are encouraged to carry out relevant research work. New technologies and methods such as unmanned aerial vehicle mapping, three-dimensional laser scanning, and InSAR monitoring have been promoted and applied, to improve the accuracy and efficiency of geological disaster investigation, monitoring, and assessment.

Publicity and education of geological disasters control. Extensive publicity and educational activities on the prevention and control of geological disasters have been carried out. Through the training courses, the public's awareness of disaster prevention and self-rescue has been improved, and mutual rescue capabilities have been enhanced. A mass monitoring and prevention system has been established to mobilize the vast number of grassroots cadres and the masses to participate in the monitoring and prevention of geological disasters.

### **3. Study case of the geological disaster rescue from Sichuan, China**

Sichuan Institute of Nuclear Geological Survey undertakes the work of geological disaster investigation, to provide technical support in exploration, design, construction, supervision, and monitoring of key geological disasters.

In terms of disaster emergency rescue, the institute is the UAV technical support unit of the Geological Disaster Emergency Technical Guidance Center of the Ministry of Natural Resources. The institute has carried out many major emergencies rescue works, obtained the latest images of the disaster area through aerial survey, and provided technical support for the disaster rescue.

In an emergency rescue of a large alpine landslide, the institute aerial survey team detected that there were cracks at the high level of the trailing edge of the landslide and there was a risk of a secondary landslide. After receiving the news, the command center quickly organized the evacuation of rescuers, which turned out to be successful in avoiding secondary casualties.

#### *3.1 Geological disasters monitoring and warning system*

Monitoring system. Sichuan Province has established a geological disaster monitoring network covering the whole province, including automatic monitoring stations, monitoring and early warning equipment and daily inspections by grassroots inspectors. High-precision monitoring instruments have also been set up in key areas.

Early warning system. To introduce modern meteorological, earthquake and geological disaster early warning system, and cooperate with China Meteorological Bureau, Seismological Bureau and other departments to release geological disaster early warning information to the masses through SMS, radio, APP and other channels.

### *3.2 Refined investigation of geological hazards*

Geological disaster investigation. Sichuan regularly conducts the investigation of hidden danger points of geological disasters every year, focusing on earthquake zones, mountainous villages and towns, important traffic trunk lines, schools, hospitals and other areas susceptible to geological disasters. During the flood season every year, engineers and technicians go to the local area to carry out disaster investigation work and provide technical support for the local government for disaster prevention and control.

Geological disaster investigation and risk evaluation. Based on analysis of background of disasters and field investigation, the Geologic hazard evaluation has been carried out. In the region of the alpine valleys in southwest Sichuan, the refined investigation works out with the analysis of slope units.

Geological hazards mapping. By drawing geological hazard risk maps, high-risk areas are identified, and guidance suggestions and information support are provided.

### *3.3 New technology utilization in geological disaster emergency rescue*

“Man-UAV” joint defense mode to carry out emergency rescue. Use UAV and real 3D technology to quickly measure and investigate the disaster site, judge the characteristics and influence scope of the disaster at the first time, and make quick decision-making suggestions for commanding rescue and resettlement of victims.

A network of in - situ sensors is deployed in disaster - prone regions. These sensors include displacement sensors, which can be installed on slopes or unstable rock masses to measure any movement with high precision. Sensors are connected to the network, allowing them to transmit data in real - time which make early forecasting possible.

Big data and machine learning. Big data analytic techniques are applied to process and analyze the massive multi-source data. Machine learning algorithms can be used to identify patterns and correlations within the data. With the utilization of advanced technologies the accuracy of potential geological disasters investigation and predication have been improved obviously.

### 3.4 Carry out geological disaster prevention and control project

Landslide and debris flow control: carry out engineering prevention and control in high-risk areas of landslides and debris flows, including the construction of retaining walls, drainage ditches and vegetation restoration.

Emergency Treatment: in view of high-risk areas, comprehensive treatment is carried out by implementing slope reinforcement, drainage engineering, debris flow dam and other engineering measures to reduce the risk of geological disasters.

Resettlement for residents: In view of extremely high-risk areas, residents will be relocated to relatively safe areas to reduce potential disaster threats.

Construction of demonstration zones for comprehensive treatment of geological disasters. Establish demonstration zones for comprehensive treatment of geological disasters in typical areas, form replicable prevention models and experiences, and drive surrounding areas to improve geological disasters prevention and control abilities.

## 4. Recommendations of enabling technologies and policies

### 4.1 From the technical aspect

With the development of science and technology, the ability of disaster prevention and control has been greatly improved.

Early warning platform supported by technology.

The application of high-resolution satellite images and drone inspection greatly enhances the accuracy of geological disasters investigation and provide support for early warning platforms.

Refined investigation.

For high hidden geological disasters, it is necessary to improve the early identification ability of hidden dangers of geological disasters. At present, subtle investigation of slope units is used to identify high hidden geological disasters, which greatly reduces potential risks and disasters.

Intelligent monitoring. Introduce advanced science and technology of automatic monitoring to improve efficiency and save labor cost.

Geological disaster slopes reinforcement, to improve the construction of disaster prevention infrastructure, and strengthen the protection of highways and other slopes;

Remediation. Restoration and protection of the ecological environment, a series of projects are carried out, such as the implementation of shelterbelt construction, soil and water conservation, to realize the sustainable control and management of the disasters.

#### *4.2 From the policy aspect*

Technicians collaborate with local government officials. Engineers go to the local area to carry out patrol investigation in the flood season, as well as supply technical support to local government to improve the ability of disaster management and prevention;

Regulations. A series of policies and regulations on the prevention and control of geological disasters have been issued to provide legal and institutional guarantee for the prevention and control of geological disasters;

Emergency evacuation drill work. Improve the emergency management and response ability at the grass-roots level, actively promote the construction of emergency plans for geological disasters in communities and towns, organize training and drills on disaster prevention and mitigation, and improve the people's emergency hedging ability.

Financial fund. Multi financial support, government funds, social capital injection, etc., to provide funding sources for disaster prevention and control.

#### *4.3 From the perspective of scientific and technological innovation cooperation:*

Building a cooperative network to form a pattern of disaster prevention and control, which involves all stakeholders like the government, enterprises, researchers, engineers and the communities.

Carrying out popularization science training. To improve the public awareness of safety, disaster prevention, and mitigation ability.

Broaden the cooperation. To share the experience of prevention and control of geological disasters with other provinces, cities and international organizations, participate in international cooperation projects, actively introduce advanced technology and management experience, and continuously improve the prevention and control ability.

Scientific research, exploring the applicable technical method and popularizing it.

### **Conclusion**

Despite the significant progress, there are still challenges. The accuracy of prediction is limited by the complexity of geological processes and the uncertainty of natural factors.

The risks of geological disasters in the alpine areas of Sichuan Province are complex and significant. We should improve the ability on prevention and control by utilization of advanced technologies and strengthen dialogue and cooperation among all stakeholders, to continuously optimize monitoring and early warning system, and to take on ecological restoration and environmental protection to ensure long-term and sustainable development. Work together to meet the challenges.

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## **FORUM 5**

### **Advanced Manufacturing**



## ADVANCED MANUFACTURING. ITALY-CHINA SCIENCE, TECHNOLOGY AND INNOVATION WEEK 2024

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**Keywords:** collaboration exchanges, mobility, joint research

In recent years, the University of Bergamo has remained steadfast in its commitment to advancing innovation through international collaboration. The China-Italy Laboratory on Advanced Manufacturing (CI-LAM), established in 2017, stands as one of the key initiatives at the heart of this mission. This bilateral platform has enabled an exchange of knowledge and expertise between Italy and China, particularly in the fields of Smart and Advanced Manufacturing. CI-LAM has become a powerful catalyst for joint research, product innovation, and the implementation of cutting-edge technologies.

Through this initiative, the University of Bergamo collaborates with some of China's most prestigious academic institutions, including Tsinghua University, as well as industrial partners in both countries. Over the years, the platform has organized activities that span various dimensions of innovation – such as the annual CI-LAM Summer School, innovation webinars, and research projects – that have consistently fostered an ecosystem of cooperation between academia and industry in the two countries.

A key milestone in our collaboration with China was the establishment of the University of Bergamo's office at the Zhongguancun International Robot Industrial Park in Beijing in December 2023. This office is designed to serve as a central hub for enhancing research, educational exchanges, and the development of further partnerships in advanced manufacturing. The focus of the office is to explore further opportunities for academic collaboration and joint research projects, while also supporting the connection between Italian and Chinese companies within the robotics and advanced manufacturing sectors.

This new office will also play an important role in expanding CI-LAM's activities to new areas of innovation, such as sustainability and interdisciplinary research, which are crucial to the future development of both our economies. In this context, we envision the creation of joint research initiatives, co-authored academic papers, and the establishment of dual PhD supervision programs that will help to bridge the gap between the academic and industrial communities in both countries. We will also support ongoing educational

activities, including the organization of specialized seminars, webinars, and conferences, with a particular focus on advanced manufacturing and related fields.

One of the main goals of our presence in China is to create further opportunities for academic exchanges, mobility, and joint research between our institutions and key Chinese universities such as Tsinghua University, Capital Normal University, and Beijing University of Technology. We aim to facilitate more collaboration, not only in advanced manufacturing, but also in other areas of mutual interest, such as sustainability, longevity, and cultural heritage. These fields align with some of the University of Bergamo's strategic priorities and are critical to addressing global challenges that require multidisciplinary collaboration. Our commitment to fostering this international partnership is also reflected in the recruitment and promotion of our educational offerings among Chinese partners.

Moving forward, the University of Bergamo intends to extend its platform for collaboration with Chinese universities and industries into new fields of innovation. Through CI-LAM platform and the close work with Chinese old and new partners, we will further contribute to the development of advanced manufacturing technologies, while also working on other interdisciplinary research areas that have the potential to shape the future of global industries.

The China-Italy Science, Technology and Innovation Forum serves as an important moment for reinforcing these collaborative efforts and fostering new connections between industry professionals, researchers, and academics from both countries. As part of our continued collaboration, the University of Bergamo remains dedicated to ensuring that the work done in partnership with our Chinese counterparts will not only lead to significant research advancements but also provide a platform for further bilateral collaboration to flourish.

I would like to thank all the participants in this forum for their valuable contributions. The discussions held here today will undoubtedly continue to inspire new projects, foster further collaboration, and lead to impactful outcomes in the field of advanced manufacturing.

## ADVANCED MANUFACTURING

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**Keywords:** advanced manufacturing, complex products, innovative technologies

Advanced manufacturing encompasses the set of innovative technologies, processes and methods to improve a company's competitiveness in the manufacturing sector, where technologies are integrated into the value chain and where high-quality products are created. In this context, key technologies help to create complex products, increase production efficiency, reuse and reduce waste and energy consumption. Italy is the second country in Europe for production, excelling in the production of machinery, fashion items, food products, automotive components and pharmaceutical products. Compared to the international trend in the sector, production was estimated to slow in the second half of 2023 as Italian factories suffered from China-led decline in demand, while borrowing costs rose as the European Central Bank sought to mitigate inflation. Despite the projections, at the end of the year 2023 the revenues of Italian manufacturing companies reached a record of 1.16 billion euros, 250 million more than 2019, consolidating the progress made in the following two years and the average annual growth rate in the Italian manufacturing sector in 2021 and 2022 was 9.1% with a remarkable post-COVID recovery.

Italy participates in the challenges of advanced manufacturing through integrated models/systems:

- Industrial Automation: Continuous integration of robotics and automated systems to improve production efficiency and reduce human error;
- Additive Manufacturing (3D Printing): Innovations in 3D printing technology that allow for more complex and customized products;
- Artificial Intelligence (AI): use of AI for preventive maintenance, quality control and optimization of production processes;
- Industrial Internet of Things (IIoT): connection of machines and systems to collect and analyse data in order to improve decision-making and operational efficiency;
- Immersive Technology: Application of augmented reality (AR) and virtual reality (VR) in training, maintenance and design.

Our country is certainly a leader in the automation sector, with companies such as Comau and ABB Italy developing cutting-edge robotic solutions and these technologies are already widely used in automotive production. The national industrial world is integrating IIoT solutions to create smart factories, and this involves the use of integrated cyber-physical systems to connect machinery, workers and products. This approach allows the adoption of new production management and supply planning techniques.

The concept of “Industry 4.0” is widely adopted in Italy, with many productions using advanced technologies to create environments with low environmental impact and to achieve highly efficient and flexible production. The combination of Italy’s creativity and technological prowess make it a key collaborator in the global advanced manufacturing landscape where such capabilities not only enhance national production capacities but also establish a global benchmark for innovation and sustainability in the sector. This revolution, as well as all the previous ones, cannot be stopped or cannot be reversed; we must be proactive to guide this disruptive progress, while always keeping in the spot humankind, with his genius and the environment, with its complexity.

On the occasion of the 20<sup>th</sup> anniversary of the Comprehensive Strategic Partnership between China and Italy, the two countries agreed that bilateral relations have achieved important cooperation results in recent years and enjoy a positive moment of development. Italy and China intend to maintain their bilateral collaboration also in the spirit of the ancient Silk Road, which for millennia, starting from the ancient trade routes, has represented the openness to dialogue and mutual knowledge between Eastern and Western civilizations. Both countries agree to implement the Action Plan, to strengthen the coordination of their respective development strategies and to deepen cooperation in various fields by strengthening cultural exchanges between their respective civil societies and fully developing the potential of the Global Strategic Partnership. The Parties intend to continue to create favourable conditions for exchanges of scientific researchers and to facilitate the emergence of new opportunities for the joint training of high-level talents in scientific and technological research involving their respective universities and research institutes. The two countries have the common goal of providing future directions for research on advanced technologies useful for promoting an effective exchange of innovation ecosystems on advanced manufacturing.

On 28 July 2024, it was agreed to implement an Action Plan for the strengthening of the China-Italy Comprehensive Strategic Partnership in various areas for the period 2024-2027 with a focus on scientific and technological innovation. The intent is to promote economic and social development through joint research in areas of common interest, such as the environment, energy, polar exploration and sustainable development. Therefore, they will continue to support cooperation for advanced manufacturing, green aeronautical technologies and strengthen cooperation in the polar field, especially in the Ross Sea area in

Antarctica where the Italian Research Station “Mario Zucchelli” and the Chinese Research Station “Qin Ling” are located. The parties intend to continue to work together, both bilaterally and multilaterally, in the area of seas and oceans and biodiversity protection. In addition, both recognize the importance of cooperation in the space field to address global challenges such as climate change, land security and monitoring, asteroid protection and space debris management.

The greater dynamism of Italian manufacturing compared to that of the other major European economies was reflected in an increase in its share of total EU exports, which grew both in intra-area trade and in trade with the rest of the world. China continues to confirm its strategic position for Italian exports: Beijing ranks among the top destinations for Italian exports globally, given that it is the main market in Asia and the second among non-European countries, after the United States. “The number and growing value of institutional missions in the country significantly promote economic relations between Italy and China, which count on a stock of Italian foreign direct investments in China of over 15 billion euros according to ISTAT data, of which over 1300 manufacturing investments that distinguish the majority of the companies present with 130,000 employees and a turnover of 33 billion euros”. China in 2023 was the fourth largest outlet market with almost 2 billion euros in machinery purchases. Despite a slight drop in Italian exports of the sector to China and some policies that do not facilitate trade, the two countries highlighted the great opportunities offered by this market and by the collaboration with Italian-Chinese companies.

In conclusion, Italy and China are united by science and innovation and have a shared vision of economic development focused on the enhancement of cultural heritage as a competitiveness factor and environmental protection as a global must, that allows these two countries to face global challenges together, certainly benefiting from synergies and trade agreements capable of enhancing their respective strengths.

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# INTEGRATION AND INNOVATION - EXPLORATION AND PRACTICING OF TECHNOLOGY TRANSFER PATHS IN BJUT

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**Keywords:** innovation, technology transfer, innovative ability, cooperation

## 1. Background and trends

### 1.1 *Sino-Italian cooperation foundation*

On November 8 this year, the talks between President Xi Jinping and President Mattarella emphasized the importance of strengthening cooperation in the fields of economy, trade, science, and technology, which coincided with the 20<sup>th</sup> anniversary of China-Italy comprehensive strategic partnership. The exchanges between universities of the two countries were fruitful, and the “China-Italy Science, Technology and Innovation Week” became an important platform for China-EU scientific and technological cooperation<sup>1</sup>.

### 1.2 *Integration and innovation become a global trend*

Under the background of globalization, integration and innovation have become an irresistible trend<sup>2</sup>. From the application of Google DeepMind in the medical field to the establishment of the Sino-Italian advanced manufacturing joint laboratory, countries have been expanding in interdisciplinary and industrial integration, and high-quality achievements in cross-border integration have emerged one after another. Countries are closely linked, and interdisciplinary integration with Industry-University-Research has been strengthened. These achievements have promoted global economic prosperity and injected new vitality into the future development of human society.

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<sup>1</sup> On the afternoon of November 8 (2024), President Xi Jinping held talks with Italian President Sergio Mattarella, who was in China for a state visit.

<sup>2</sup> MA 2016.

### 1.3 *Colleges and universities face opportunities and challenges*

Under the current background, colleges, and universities, as the source of scientific and technological innovation, face both opportunities and challenges<sup>3</sup>. Making a reasonable layout and realize the deep integration of interdisciplinary, cross-disciplinary and cross-border has become a problem that colleges and universities must think about. According to the preliminary investigation, universities should pay attention to the global development trend and regard it as one of the core driving forces of their own development. Specifically, it can be achieved through the following three aspects: innovation drives industrial upgrading and transformation, enterprise demand drives innovation and development of universities, and universities and enterprises integrate with Industry-University-Research to cultivate high-level talents. These measures help universities to meet the challenges and lay a solid foundation.

## 2. The foundation and characteristics

### 2.1 *School profile*

Founded in 1960, Beijing University of Technology is the only “211 projects”<sup>4</sup> key construction university in Beijing. In 2017, it entered the ranks of national double-class construction universities. The school has a solid foundation in discipline layout, talent cultivation, teacher reserve and scientific research.

In addition, the school attaches great importance to international school-running exchanges, such as Beijing-Dublin International College and the “Belt and Road” China-Poland University Alliance to build bridges for international talent flow.

### 2.2 *Scientific and technological strength*

In terms of scientific and technological innovation, the school is guided by “four aspects”, that is, facing industrial demand, scientific and technological frontier, economic development and life health. The school has made important progress in the fields of future materials, manufacturing, information, energy and health. For example, in the future manufacturing direction, the school successfully industrialized the key components of industrial robots and developed new materials such as layered bismuth oxide ferroelectric

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<sup>3</sup> ZHANG 2024.

<sup>4</sup> The “211 Project” refers to the construction of about 100 institutions, university, colleges, of higher learning and a number of key disciplines oriented to the 21<sup>st</sup> century in China.

films; In the future information field, the school has built a traffic big data platform, which provides technical support for urban traffic management and builds a digital brain. In addition, in the future health field, the school has also developed a series of high-tech products such as ophthalmic medical chips, making unremitting efforts to continuously improve the quality of life of patients.

In addition, the school attaches great importance to the integration of culture and technology, and its achievements include the protection of historical buildings, the exhibition design of museums, and the restoration of ancient cultural relics. Such as courtyard restoration, public service advertisement design of The Chinese Dream, landscape The Qianhexielu (Lotus Blossoming) Bridge on the Northern Stretch of the Grand Canal in Tongzhou, and restoration of cultural relics by using 3D printing technology.

### **3. Exploration and innovation**

#### *3.1 Development Goals and Paths*

Beijing University of Technology has defined its development goals. By 2030, several disciplines will move to the ranks of world-class disciplines. By 2060, the ranks of world-class universities will be listed. In order to achieve this goal, the school has formulated the development path of “grasping high-quality development content, stimulating high-quality development momentum and building high-quality development guarantee”.

#### *3.2 Orientation and mode of achievement transformation*

In terms of transfer and transformation, the school insists on promoting industrial innovation and integrated development with scientific and technological innovation and promoting the strategic positioning of high-quality scientific and technological achievements to form new quality productivity as soon as possible. And put forward the development model of “three highs and five orientations”: “three highs” refers to high-level scientific and technological innovation, high-efficiency achievement transformation and high-level organized scientific research; The “five orientations” include innovation-driven change, stimulating vitality and willingness to change, improving the system and being able to change, equipping teams to help change, and cooperating with schools and places to successfully change. Although the mechanism system is gradually improved and the organized scientific research work has achieved initial results, we still find that there is a phenomenon of “broken bridge” in the process of scientific and technological achievements in schools from laboratory to engineering to industrialization, that is, the

supporting work for the transformation of scientific and technological achievements still needs to be strengthened.

In order to solve this problem, the school proposes to build a new ecological circle with the school as the core and the resources of government, schools and enterprises. In 2023, the school, Chaoyang District Government and Beijing Enterprises Group Company Limited jointly established the “Beijing University of Technology Shan-He-Wan-Gu Innovation Zone”, becoming the first innovation zone around universities jointly established by the government, universities and enterprises in Beijing.

The innovation zone aims to promote universities to focus on industrial demand, enterprises to aim at high-quality innovation, and the government to build a policy ecology to realize the integration of innovation resources and industrial, form integration of innovation and industrial chain, and organize the transfer and transformation of scientific and technological achievements in a multi-dimensional, multi-channel and all-round way.

At present, the innovation zone has settled in 48 innovation and entrepreneurship projects, with an occupancy rate of 100%. In the future, the innovation zone will expand its scale in combination with the needs of teams inside and outside the school and strive to build into an internationally influential artificial intelligence industry gathering place.

#### **4. Summary and Prospect**

Beijing University of Technology has made remarkable achievements in the exploration and practice of technology transfer path and has effectively promoted the transformation and application of scientific and technological achievements by building a “three highs and five turns” model and establishing an innovation zone. These efforts not only show the innovative spirit and practical ability of the school but also make positive contributions to improving the national innovative ability. In the future, the school will continue to adhere to the spiritual core of “never cease to be the body, never cease to be the Tao”, constantly deepen exchanges and cooperation with universities and enterprises at home and abroad, jointly explore more possibilities of integration and innovation, and inject a steady stream of power into scientific and technological progress and social development.

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## ADDITIVE TECHNOLOGIES BETWEEN INNOVATION AND SUSTAINABILITY

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**Keywords:** technologies, additive manufacturing, sustainability, advanced manufacturing, material durability

One of the paradigms of modern manufacturing is the creation of added value through innovative products made with increasingly advanced materials and processing technologies, all within a perspective of sustainability and circularity.

As observed in analyses and documents from the World Economic Forum, sustainability is one of the pillars of advanced manufacturing. Sustainability itself is interpreted from various perspectives, including materials, with a particular focus on advanced materials. The field of advanced materials encompasses all classes of materials: polymers, composites, ceramics and metals (such as aluminium, titanium, stainless steel, nickel alloys, and other superalloys). Once again, referring to data from the World Economic Forum, sustainability is a pervasive theme that extends to the connection between sustainable metals and the circular economy; at the same time, sustainable metals are linked to 3D printing.

It is crucial, first and foremost, to understand the current expectations of advanced manufacturing regarding the products and the materials used in their production. Today, the field of metallic and non-metallic materials is increasingly connected to a series of crucial aspects influencing both performance and sustainability.

One of the most relevant elements is material performance, which must ensure adequate mechanical characteristics for various industrial applications. Key requirements include structural strength, the ability to withstand high mechanical stresses, and resistance to extreme environmental conditions. Another key factor is material lightweighting, which is particularly essential in the aerospace, automotive and civil engineering sectors, where weight reduction contributes to improved energy efficiency and overall product performance. Corrosion resistance is also a fundamental parameter, especially for materials designed to operate in aggressive environments or in contact with chemicals. Additionally, adaptability to high temperatures is essential in many industrial fields, such as the energy and metallurgy sectors, where materials must maintain their properties even under extreme operating conditions.

Another increasingly important aspect is customization and functionalization, which apply to both final products and the materials themselves. Modern industries require tailored solutions that can meet specific technical and aesthetic needs. The ability to modify material properties based on application requirements allows for the creation of products with unique characteristics, enhancing their efficiency and versatility. This trend is driving the development of innovative materials that, through advanced processes, can be optimized to meet specific requirements of strength, conductivity, flexibility or other functional properties.

Finally, sustainability is a central theme in contemporary industry, an essential goal to reduce the environmental impact of material production and usage. The ability to recycle and reuse raw materials is becoming a determining factor in material selection, helping to limit the consumption of natural resources and reduce production waste. Moreover, material durability is another key element to ensure longer product lifespans and reduce the need for frequent replacements, providing both economic and environmental benefits.

In this ever-evolving scenario, the manufacturing industry is called upon to find innovative solutions that combine high performance, customization and sustainability, placing increasing emphasis on research and development of new materials capable of meeting future challenges.

Regarding the 3D printing of metallic materials, today's technological landscape offers various solutions capable of addressing, at least in part, the needs of multiple industrial sectors. These advanced technologies enable the creation of complex metallic components with ever-increasing levels of precision and performance, opening new possibilities for industrial production. Currently, there are three main categories of additive technologies, distinguished by their operating principles and primary applications:

- Laser Powder Bed Fusion (LPBF, EBM), particularly suitable for high-precision components and complex geometries;
- Direct Energy Deposition (DED), ideal for the repair and enhancement of existing parts;
- MEX and BJ Additive Manufacturing, used for the fabrication of structures with advanced materials and specific mechanical properties.

With the evolution of these technologies, metal 3D printing is becoming an increasingly viable alternative to traditional manufacturing methods, enabling the production of innovative components with complex geometries, superior mechanical properties and reduced production times. The continuous development and improvement of these techniques promise to further expand their application potential, contributing to the digital and sustainable transformation of the manufacturing industry.

Given the qualitative level and maturity achieved in these fields, it is now possible to assert that Additive Manufacturing (AM), particularly in the context of metal 3D

printing, can serve as an enabling technology to meet expectations regarding performance, functionalization, customization and sustainability. Current additive technologies allow for product lightweighting and functionalization through reduced apparent density and controlled porosity structures, even leading to the development of Functionally Graded Materials (FGM), which exhibit variable porosity and mechanical properties.

Metal AM is also an enabling technology for developing new materials, whether they are traditional materials with enhanced properties or entirely new high-performance materials. Furthermore, AM reduces the time to market for new materials. Additionally, it plays a crucial role in advancing shape-memory materials and 4D printing. The ability to print optimized shapes for specific product applications, potentially without complexity limitations, makes it a revolutionary technology for a wide range of sectors, from personalized medicine, where biocompatible implants can be custom-made, to aerospace, where topological optimization reduces weight while improving performance.

Advantages include:

- Complex geometries;
- Component lightweighting;
- Shape optimization;
- Achievement of near-net shape forms;
- Material replacement.

Another crucial point is sustainability: AM enables efficient resource use, drastically reducing material waste. On-demand production and the ability to regenerate or recycle metal powders from end-of-life products contribute significantly to circular economy principles. Recycled powders for Additive Manufacturing can come from end-of-life product transformations or by-products of traditional manufacturing processes. Besides being reusable as feedstock for AM technologies, they can also serve as secondary raw materials for other manufacturing processes.

The increasing number of applications across various manufacturing sectors, including automotive, aerospace, healthcare, fashion, architecture and jewellery, confirms the technological maturity and capability of AM to meet industry needs and expectations.

Additive technology boasts a history of over 30 years. Initially developed for prototyping, it has recently experienced tremendous growth in various industrial applications, especially in metallic materials. The next decade will be interesting to watch, with numerous challenges to overcome. Regardless of what lies ahead, it is already clear that additive technologies not only foster technological innovation but also serve as a fundamental pillar for transitioning to a sustainable industrial model, where advanced materials and efficient processes contribute to greater economic competitiveness and environmental responsibility.



## SERVING THE INDUSTRIAL DEVELOPMENT OF HUNAN BUILDING AN INNOVATIVE TECHNOLOGY ENGINE

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**Keywords:** innovation, technology engine, creative platform

The Yuelushan Center for Industrial Innovation is one of the four provincial laboratories in Hunan. This center was established as an open and collaborative innovation platform under the cooperation framework between the Hunan Provincial People's Government and the Chinese Academy of Engineering. The decision-making support is provided by an expert committee, with innovative teams serving as the core force, fully leveraging the resources of academicians. It relies on key industrial parks, universities, research institutions, and enterprises as critical pillars. The center is committed to offering joint research on common technologies and public innovation services for the development of the entire industrial chain and the entire product life cycle within the province. The center operates under a director responsibility system led by the council, with its four laboratories serving as vital components of the center.

The Xiaoxiang Laboratory focuses on three major missions: major original innovation in intelligent manufacturing, research on key common technologies, and intelligent empowerment. It promotes the accelerated transformation and upgrading of Hunan's manufacturing industry in six research directions. The laboratory has won nearly 30 national science and technology awards, and more than 200 technologies have filled domestic gaps in large aircraft. It has created more than 60 provincial-level intelligent manufacturing demonstration enterprises and more than 100 demonstration workshops and more than 40 provincial-level industrial Internet platforms. These achievements have contributed to the perfection of the intelligent manufacturing industry system.

The Lushan Laboratory focuses on four major research areas, integrating foundational studies such as intelligent human-computer interaction design technology, complex scene perception systems, industrial design big data platforms, and other core technologies. Our aim is to empower industrial upgrading through innovative industrial design. Currently, the laboratory is in the process of establishing a national-level industrial design research institute. In parallel, we are developing an automatic audio and video generation creative

platform, which provides technological and design support to meet the cultural and technological integration needs of the Hunan Broadcasting System.

The Hengshan Laboratory focuses on the strategic needs of high-quality development, aiming to establish an industrial quality technology integration and collaborative innovation ecosystem, and conducts research on strategic, forward-looking, and basic quality technologies and scientific issues. Focusing on fields such as Beidou navigation, rail transit, and engineering machinery, we are establishing 24 metrology standard research laboratories. Our developments, including the high-precision plane crystal flatness measuring instrument and the 0.005-grade three-phase wide-band AC power standard meter, have already been put into use. Notably, the “closed-loop self-inspection of flat crystal surface shape absolute measurement” technology has achieved international leading standards.

The Dongting Laboratory focuses on fields such as food resource protection and processing utilization, and conducts basic, frontier, and public welfare scientific research around seven directions to cultivate the internal driving force and development momentum of scientific and technological innovation in food enterprises. In June 2023, invited by the NATURE magazine, it introduced important progress in the research on the activity and nutrition of citrus functional components to the world in its main issue “Nature insideview: Nutrition Research in China”.

The planning for development of Yuelushan Center for Industrial Innovation is to focus on the “five bases” and “five links” of industry, following the principles of “multiple participation, joint construction and sharing, collaborative innovation, and efficient integration”, to provide integrated and full-chain innovation services for Hunan’s industry, and strive to be an important accelerator for the quality improvement and upgrading of Hunan’s industry. With the goal of “serving the development of Hunan’s industry and creating an innovative technology engine”, we focus on five core tasks: “research on key core technologies, cultivation of emerging industries, construction of public research and development platforms, creation of major scientific and technological infrastructure, and construction of an enterprise innovation ecosystem” to provide scientific and technological support and leadership for the realization of the beautiful blueprint of “Three Highs and Four News”.

Our center provides public services. Through project managers, we deeply explore the key technological challenges and common technology needs of industrial enterprises in Hunan. By matching specialized research teams from around the world, we address these technological issues and promote the application of innovative research results for enterprises. Additionally, we collaborate with local governments, industrial parks, and leading enterprises in the industrial chain to establish regional sub-centers, industrial innovation consortia, and joint laboratories. These efforts are part of our active initiative to build an innovative network system.

Focusing on the key technology needs of enterprises within Hunan Province, we actively conduct research on key technologies in the industry. In 2024, 170 key technological needs of enterprises in Hunan Province were condensed. Focusing on the technology needs of key fields such as advanced manufacturing, artificial intelligence, and new materials in Hunan Province, 53 key common technology research projects were laid out in the early stage, which will promote the solution of 43 key technical problems, obtain 39 new products, 134 patents, and 20 software copyrights. We normalize the promotion of industry-university-research cooperation of Hunan enterprises. The project manager system was first initiated in Hunan Province, and the current team has more than 300 people. Through the flexible talent utilization mechanism of “multiple channels” and “project-based”, a “project-based” expert database has been established, with nearly 2700 project contract expert teams. Up to October 2024, project managers have contacted 1292 enterprises in the province, surveyed more than 2000 enterprises’ technical needs, organized experts to investigate 567 enterprises, and are effectively promoting cooperation with more than 180 enterprises.

The center fully serves Hunan’s industrial industry and promotes the high-quality development of the industry. From 2023 to the end of October 2024, it directly served 519 enterprises in the province, signed 738 enterprise cooperation projects, with a financial investment of 7,224,000 yuan and guiding by an enterprise investment of 700,000,000 yuan.

We strive to become an important partner in Hunan’s industrial community, an important window for linking global innovation resources, and the “Fraunhofer Institute” and “Industrial Technology Research Institute of Taiwan” in Hunan, providing source support for Changsha to build a global R&D (Research and Development) center city and for Hunan to build an important national advanced manufacturing highland and a scientific and technological innovation highland.



# ROBOTICS AND ARTIFICIAL INTELLIGENCE FOR INTERACTION TECHNOLOGY

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**Keywords:** robotics, artificial intelligence, interaction technology, internet-of-skills

Robotics is a young and rapidly evolving science. Robots were first widely used in industry starting in the 1960s. The main factors that drove their adoption in the manufacturing industry, particularly in the automotive sector, included the reduction of production costs, increased productivity, improved product quality standards, and, not least, the possibility of eliminating harmful or repetitive tasks for workers.

Compared to the past, today a robot's actions are no longer a predefined sequence of movements but are carried out automatically through a control system that governs motion in relation to what occurs in the environment. Hence, robotics is defined as the “intelligent connection between perception and action,” encompassing a cognitive dimension (decision-making and planning actions), a sensory dimension (partial knowledge of reality and data collection), and an actuation dimension (physical actions necessary to achieve a goal). Unlike Artificial Intelligence (AI), which is often mistakenly conflated with robotics, robotics also involves mechanical bodies that interact directly with the physical world.

## 1. Interaction Technology

We are the protagonists of a technological revolution in which Robotics is destined to play a driving role for a new generation of autonomous devices which, through the ability to learn, will be able to collaborate with human and interact with the external environment. Hence the neologism *IAT (InterAction Technology)* introduced to explain how the convergence between Robotics and AI will project us towards a new generation of intelligent devices that will be the missing link between the digital world and the physical one<sup>1</sup>. In this sense, IAT represents the natural evolution of ICT and lays the foundations for a real symbiosis

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<sup>1</sup> BICCHI, SICILIANO 2021.

between human and machine thanks to an increasingly intuitive technology, which will make it possible to use robots with the same ease with which we use today common *devices*.

If previously robots were confined for safety reasons to spaces far from humans, in the new generation factories they have effectively become *cobots*, which cooperate together with the worker in a safe and reliable way, or they are equipped with autonomy to move and work even in presence of uncertainty and variability of the environment. Cobots represent a key element of Industry 5.0, characterized by the integration of humans and intelligent machines. Unlike traditional industrial robots, cobots are designed to safely interact with operators without the need for protective barriers. Thanks to lower costs and ease of use, cobots are increasingly adopted by small and medium-sized enterprises (SMEs), enabling them to leverage the opportunities provided by automation.

We will have technology capable of revolutionizing not only the production approach, but also our daily life. Reduction of risks and work fatigue, improvement of the production processes of material goods and their sustainability, safety, efficiency and reduction of the environmental impact due to the transport of people and goods, physical assistance to the disabled or elderly, progress in diagnostic techniques and surgeries are all examples in which the new technologies of interaction can be a tool at the service of humans.

## **2. The Expansion of Robotics: From Industrial Robots to Service Robots**

In addition to its traditional use in the industrial sector, Robotics is finding new applications in fields such as healthcare, logistics, and services. Robotic surgery, for instance, enables less invasive procedures with greater precision, leading to faster recovery times. Hospital assistance benefits from robots used for sanitation and material transportation, reducing exposure risks for healthcare workers. In the pharmaceutical sector, Robotics ensures higher standards of precision and safety.

In the coming years, thanks to Artificial Intelligence, robots will become increasingly adaptable and autonomous, improving the quality of interaction with humans and optimizing operational performance. Cloud computing and 5G are revolutionizing Robotics, allowing robots to process data in real-time and enhancing their responsiveness. Artificial vision enables more advanced programming, while predictive maintenance optimizes operational efficiency. AI is also driving significant improvements in sustainability by optimizing resources to reduce waste and emissions.

## **3. From Internet-of-Things to Internet-of-Skills**

5G is expected to contribute to promoting the efficiency of robotic systems, which will pave the way for a new generation of robots controlled via wireless communication and

at the same time equipped with new processing and data storage resources via the cloud. Robots operating in environments co-inhabited by humans in the near future will need to have the ability to interact, make decisions and react flexibly to unexpected events. To do this, a robot must be able to probe the environment and gain awareness of its surroundings. Improving sensory skills and processing information from the outside is essential and this will be possible through the use of exteroceptive sensors such as distance, vision and contact sensors which will have to be increasingly sophisticated. Deep learning-based image and sound processing techniques have increased the need for high computational resources. Even if the computing capacity and the miniaturization of processors have improved in recent years, one cannot think of housing all the necessary computing capacity in a robot. Being able to connect a robot via a wireless connection with one or more external computers represents an enormous wealth that can open the door to a new generation of robots with unprecedented characteristics of autonomy, safety and reliability. That said, in order for a robot to work correctly, the connection must allow for the transfer of a large amount of data per second and that the time taken to transfer the data be sufficiently small and above all predictable, i.e. with constant latency.

With 5G, robots will eventually be able to be controlled dynamically in real time and be connected with people and machines both locally and globally. It is therefore understandable how *IoT* (*Internet-of-Things*) can be overcome by *IoS* (*Internet-of-Skills*), a “tactile internet” to allow a remote physical experience through haptic devices that combine with the skills, for example, of the drone operator or the surgeon dealing with an operation performed using a remote robotic system.

Ultimately, the new paradigm of interpenetration between the emulation of the digital twin and the operation of physical reality (*phygital twin*) redesigns in an extraordinary way not only the industrial field but also promises to have an impact in other fields of application: agri-food, medical-health, urban mobility, hostile or poorly structured environments<sup>2</sup>.

From the perspective of Robotics, there are many challenges ahead, but the main one will be integrating these technologies in a sustainable and inclusive way, ensuring that automation enhances quality of life without creating new inequalities.

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# CHINA-ITALY COLLABORATION ON EV POWERTRAIN TECHNOLOGY. CHINA-ITALY COOPERATION TO PROMOTE ELECTRIC DRIVE INTEGRATION TECHNOLOGY FOR NEW ENERGY VEHICLES

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**Keywords:** cooperation, exchange, powertrain technology, electric vehicles, electric drive

## 1. Cooperation background

Italy and China have been keeping good relationship for many years. On July 29, 2024, Chinese President Xi Jinping met with Italian Prime Minister Meloni in Beijing and agreed that China-Italy relations have maintained a positive momentum of development. The next day, China issued the Action Plan on Strengthening the People's Republic of China and the Republic of Italy Comprehensive Strategic Partnership (2024-2027), which also marked that the cooperation between China and Italy will continue to strengthen.

On November 26, 2019, the Ministry of Science and Technology and the Italian University of Education jointly held the 10th China-Italy Innovation Cooperation Week. At the opening ceremony, NEVC signed a strategic cooperation agreement with the Politecnico di Torino. Wang Zhigang, Minister of Science and Technology of China, Sui Zhenjiang, Vice Mayor of Beijing, Minister of Education and University Research of Italy Lorenzo Fe Lamonti and other leaders witnessed the signing ceremony.

In fact, as early as September 23, 2018, NEVC started to cooperate with Politecnico di Torino and signed a framework cooperation agreement, marking a great start of the tie between NEVC and Politecnico di Torino. In recent years, NEVC and Politecnico di Torino have had frequent technical exchanges and established a good cooperative relationship. On April 12, 2023, Politecnico di Torino visited NEVC to discuss the joint training of doctoral students, joint application for projects, applications for European projects, advanced technology incubation and other matters. On June 17, 2023, Politecnico di Torino visited NEVC to discuss the renewal of strategic cooperation agreement, the exchange of personnel visits, the establishment of a joint laboratory, advanced technology incubation and other issues. On September 12, 2023, Politecnico di Torino visited NEVC to implement the aforementioned cooperation. On November 7, 2024, the delegation from Politecnico

di Torino visited NEVC. NEVC also visited Politecnico di Torino in 2023 and 2024 to strengthen its ties with the university.

## **2. Technical cooperation**

One successful innovation project between NEVC and Politecnico di Torino is to jointly develop 800V high-power-density SiC (Silicon Carbide) motor inverter which achieves a maximum power density of 75kW/L. The 1200V DCM1000 SiC power modules produced by Danfoss in half-bridge provide a small footprint area, low stray inductance and low thermal resistance. The proposed inverter has been designed to replace an existing inverter on a commercially available high-end vehicle (in China market). TRL 7 prototype has been built with an IP67 minimum case and 9 anchor points designed to match one of the original inverters currently used on the target vehicle, Automotive compliant (EMI emissions & mechanical roughness). Three 800 um thick copper PCBs interconnected with copper standoffs, and the three boards house several 900V CeraLink capacitors in different formats to reach the required capacitance of 128 uF. 6 low profile CeraLink capacitors are placed in correspondence of the DC terminals of the power modules to minimize commutation loop inductance. Thanks to the advanced design, the prototype achieved high power density with excellent EMC performance.

The designed inverter was exhibited at the ECCE conference in 2022, where it attracted lots of attention from academic and industrial partners. The project team has published several papers and won the First Prize Paper Award of IEEE Transactions on Industry Applications in 2024.

## **3. Output and achievement**

To further strengthen its ties, since 2023 NEVC and Politecnico di Torino have established the New Energy Vehicle Joint Lab, with two offices in both Beijing and Turino. Main responsibilities include joint cultivation and joint research and development, translation and Promotion of Research Results, academic exchange activities, recruiting high-end talents, promoting Italian innovative enterprises to settle in Beijing, and innovation & entrepreneurship competition.

From November of 2023, NEVC and the Politecnico di Torino have jointly supervised two doctoral students in the Joint Lab, from mechanical engineering and electrical engineering.

The strategic partnership between NEVC and Politecnico di Torino will continue, with plans to strengthen cooperation in the next years to facilitate the implementation of projects and achieve greater milestones.

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# ADVANCED MANUFACTURING FOR INCLUSIVITY: DIGITAL ASSISTANCE AND ROBOTICS FOR DIVERSE COGNITIVE PROFILES

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**Keywords:** inclusive manufacturing, artificial intelligence, collaborative robotics, digital assistance

## 1. Introduction

Integrating neurodiverse individuals into the workforce remains a significant challenge in modern manufacturing. Although neurodivergent individuals comprise 20% of the global population, only 29% of autistic adults attain full-time employment, despite 85% wanting to work. Additionally, 62% of employees believe companies provide insufficient support for neurodivergent colleagues<sup>1</sup>.

Manufacturing relies on standardized workflows that assume uniform cognition, creating barriers for diverse workers. Traditional instructions, like text manuals and static visuals, lack flexibility. While robots boost productivity, their integration into human tasks is limited by adaptive intelligence. Combining human-robot collaboration, adaptive digital systems, and AI-driven assistance enables real-time, context-aware support, enhancing inclusivity and efficiency. This study reports an overview of an innovative technological ecosystem designed to integrate neurodiverse operators into industrial workflows. By combining advanced hardware, artificial intelligence (AI), and assistive technologies, the proposed framework enables real-time cognitive load assessment, adaptive robotic assistance, and intelligent task management, enhancing both productivity and inclusivity.

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<sup>1</sup> DOYLE 2020, 108-125.

## 2. Methodology

The proposed approach is structured into several key phases:

- **Data Acquisition:** This phase involves the systematic collection of physiological and behavioural data, environmental conditions (temperature, noise, lighting), and measurable aspects of the production process<sup>2</sup>. Physiological data includes heart rate variability and eye-tracking patterns, while behavioural data captures movement efficiency and response times to tasks. Environmental conditions are monitored via integrated IoT sensors to identify potential stressors that could impact cognitive performance<sup>3</sup>.
- **Cognitive Load Estimation** – A fuzzy logic-based algorithm is employed to estimate the operator's cognitive load in near real time. This approach assigns weighted values to key parameters such as task complexity<sup>4</sup>, frequency of errors, and operator physiological data<sup>5</sup>, producing a dynamic estimation that continuously adapts to ongoing task performance<sup>6</sup>.
- **Technology Selection:** Classification algorithms are used to identify and implement the most effective assistive technologies. Real-time cognitive load metrics are evaluated and matched with a predefined decision tree to ensure that appropriate support tools are dynamically deployed without disrupting the workflow.
- **Human-Robot Interaction and Adaptive Learning:** the support system undergoes continuous refinement through machine learning techniques to ensure dynamic adaptation to user needs<sup>7</sup>. Robotic systems with AI-driven perception assist operators by identifying task complexity, providing step-by-step guidance, and correcting errors in real time. Feedback loops from human-machine interactions enhance predictive accuracy and improve the efficiency of deployed assistive technologies over time<sup>8</sup>.

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<sup>2</sup> AHMAD, KELLER, ROBB, LOHAN 2023, 2027-2041.

<sup>3</sup> CARVALHO, CHOUCHENE, LIMA, CHARRUA-SANTOS 2020, 55.

<sup>4</sup> BLÄSING, BORNEWASSER 2021, 102.

<sup>5</sup> VANNESTE, RAES, MORTON, BOMBEKE, VAN ACKER, LARMUSEAU 2021, 567-585.

<sup>6</sup> LI *et al.* 2024, 1479-1496.

<sup>7</sup> ADDONA, BRACCO, BETTONI, NISHINO, CARPANZANO, BRUZZONE 2018, 455-458.

<sup>8</sup> XIE *et al.* 2022, 285-288.

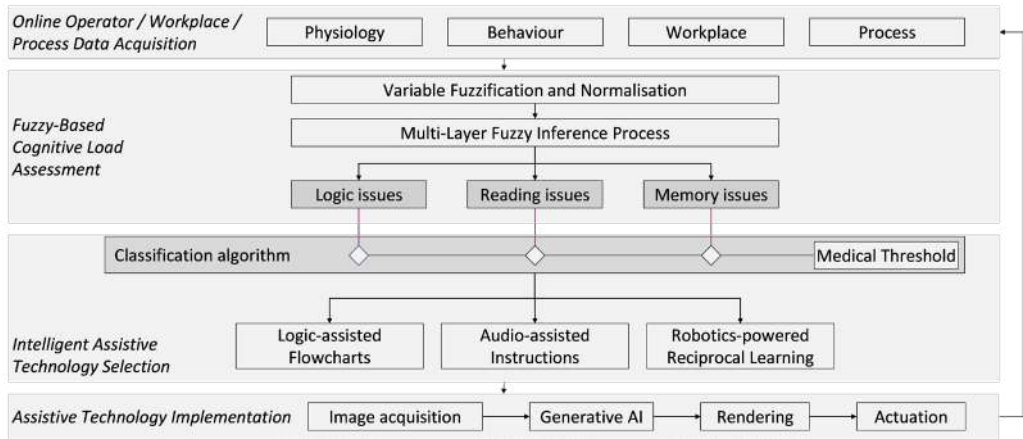


Fig. 1. Illustrates the conceptual framework of the proposed system, highlighting the workflow from data acquisition to cognitive load estimation, robotic assistance, and adaptive learning.

### 3. Assistive Technologies

Three primary assistive technologies have been developed to enhance the inclusivity of manufacturing environments.

#### 3.1 Logical Support for Assisted Assembly

An intelligent vision system is employed to detect errors in assembly operations, particularly those resulting from misinterpretation of instructions due to neurodiversity. Errors are classified using machine learning algorithms and then processed by a generative AI system. Such system then generates personalized corrective instructions, which are further simplified into flowcharts. The simplification of instructions helps reduce the cognitive strain on operators, making the assembly process more intuitive and less prone to errors<sup>9</sup>.

#### 3.2 Audio-Assisted Assembly

An audio-assisted system was developed for individuals with reading difficulties, such as dyslexia<sup>10</sup>. It integrates generative AI with text-to-speech conversion to provide real-time

<sup>9</sup> FAN, SIMEONE, ANTONELLI, CATALANO, PRIARONE, SETTINERI 2025.

<sup>10</sup> FAN, SIMEONE, ANTONELLI, CAGGIANO, PRIARONE, SETTINERI 2024.

auditory guidance. Textual instructions are converted into speech, with adjustable speed and language to match operator preferences. Images are acquired and processed by intelligent vision modules to detect points in the assembly process requiring additional clarification. Continuous refinement through operator feedback enhances adaptability, ensuring a more effective and personalized user experience<sup>11</sup>.

### 3.3 Reciprocal Learning in Human-Robot Collaboration

This system is specifically designed to address memory-related challenges in manufacturing tasks. A bidirectional collaboration framework enables operators and robotic systems to support one another, ensuring that operators with memory impairments can efficiently follow assembly sequences without cognitive overload. Robots assist operators in tracking task sequences and recalling procedural steps, while operators contribute to improving object recognition capabilities in the vision system. This approach enhances precision, reduces cognitive workload, and dynamically adjusts task instructions based on real-time operator performance<sup>12</sup>.

## 4. Implementation and Experimental Results

The developed framework was tested under controlled conditions, simulating various neurodiversity profiles. Key findings are summarized in Table 1, which outlines performance improvements in different assistive implementations.

Assistive Technology	Instruction Processing Time Reduction	Error Detection Speed Improvement	Assembly Error Reduction	Overall Efficiency Gain
Logical Support	30%	50%	45%	Improved workflow adaptability
Audio Assistance	47% (from 27.8s to 14.8s)	Near-instantaneous (from 45s to 2s)	62%	61%
Reciprocal Learning	35%	60%	Enhanced precision in object recognition	Improved long-term task efficiency

<sup>11</sup> MORRIS, CHEN 2021, 576-580.

<sup>12</sup> SIMEONE, FAN, ANTONELLI, CATALANO, PRIARONE, SETTINERI 2024, 5-8.

The results show that each assistive technology significantly improved multiple performance metrics. Logical support reduced errors from instruction misinterpretation, while audio assistance facilitated intuitive instruction-following, markedly decreasing processing and correction time. Reciprocal learning had the greatest impact on adaptive error correction, continuously improving robotic recognition through operator feedback. Integrating these technologies minimized task interruptions, reduced cognitive fatigue, and enhanced operator engagement. Moreover, iterative system refinements demonstrated that real-time adaptability substantially improves long-term usability and worker acceptance.

## 5. Conclusions

Results confirm that advanced assistive technologies and robotic collaboration significantly improve workplace accessibility for neurodivergent individuals. By reducing errors, task duration, and cognitive load, the proposed framework fosters inclusivity. Future research will focus on integrating multimodal assistance, incorporating visual, auditory, and textual support, enhanced by real-time adaptive algorithms and predictive analytics to anticipate challenges. Evaluations across diverse industrial settings will assess scalability and long-term effectiveness. This study contributes to the development of equitable workplaces, reducing employment barriers and advancing inclusivity across industries.

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## APPLICATION OF TWO KINDS OF MICRO AND NANO MATERIALS IN ADVANCED MANUFACTURING FIELD

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**Keywords:** nano materials, advanced manufacturing, environmental control

My research area includes power battery manufacturing, LNG ship manufacturing, precision electronic components manufacturing, high-end pharmaceutical wafer chip manufacturing and aerospace materials related fields, which are also comparative advantages in China. From my perspective, *advanced manufacturing* refers to the comprehensive application of advanced technology in all aspects and the whole process of production, with the aim of achieving high quality, high efficiency and low resource consumption. One of the key conditions to achieve these effects is the precise control of environmental conditions within the manufacturing process, where temperature, humidity and cleanliness are particularly important. For example, in the increasingly prominent field of lithium battery production, the coating winding and liquid injection stages have extreme requirements for environmental temperature and humidity. During the coating stage, cathode material slurry is uniformly applied on the liner in the coating process, and the solvent is volatilized in a dry controlled environment<sup>1</sup>.

In the winding stage, the humidity and dew point temperature of the environment should be maintained below the -35° degrees. More strictly, during the injection of electrolyte in the liquid injection, the dew point temperature of the environment should be lower than -45° degrees, resulting in an ambient water content in the environment of about 0.1mg/m<sup>3</sup>. Another illustrative example is the LNG ships, a top manufacturer in shipbuilding, the liquefied gas tanks in these ships must be welded using special material, such the invar steel<sup>3</sup>. In the welding process of invar, it is imperative that the welding interface remains entirely free of condensation. Should moisture be present at even a single weld point, the entire adjoining section of Invar would need to be re-welded. Consequently, welding environments must be both cool and extremely low in humidity, to the extent that workers inside the compartment

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<sup>1</sup> LIU *et al.* 2021; HAWLEY *et al.* 2019.

<sup>2</sup> YIN *et al.* 2022.

<sup>3</sup> KIM *et al.* 2020.

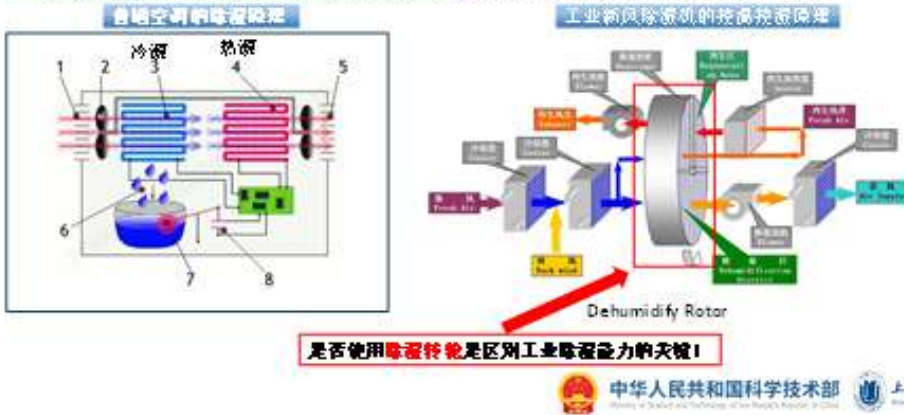
must avoid perspiring. The ability to control temperature and humidity with such precision in a large ship compartment is itself a clear demonstration of advanced manufacturing capability.

To achieve such a high humidity control capability, ordinary air conditioners can't be used. The diagram on the left (Fig.1) illustrates the principle of dehumidifier feature of ordinary air conditioners. In such systems, air from a sealed space is drawn into the unit, where it is cooled by the refrigeration component. As the temperature drops, moisture condenses out of the air and is expelled through the system's condensate drain. The remaining air is restored to the set temperature by the heating. However, dehumidification by cooling alone is theoretically limited to a dew point of 0°C. In practical operation, effective dehumidification becomes unfeasible once the dew point reaches approximately 5°C. At this stage, the air may still contain up to 5 g/m<sup>3</sup> of moisture, which far exceeds the stringent requirements of advanced manufacturing environments. Consequently, conventional air conditioners cannot meet these demands.

## 工业新风除湿机 Industrial Fresh Air Dehumidifier

工业新风除湿机是控制AM生产环境的必备设备

Industrial fresh air dehumidifier is the necessary equipment to control the AM production environment

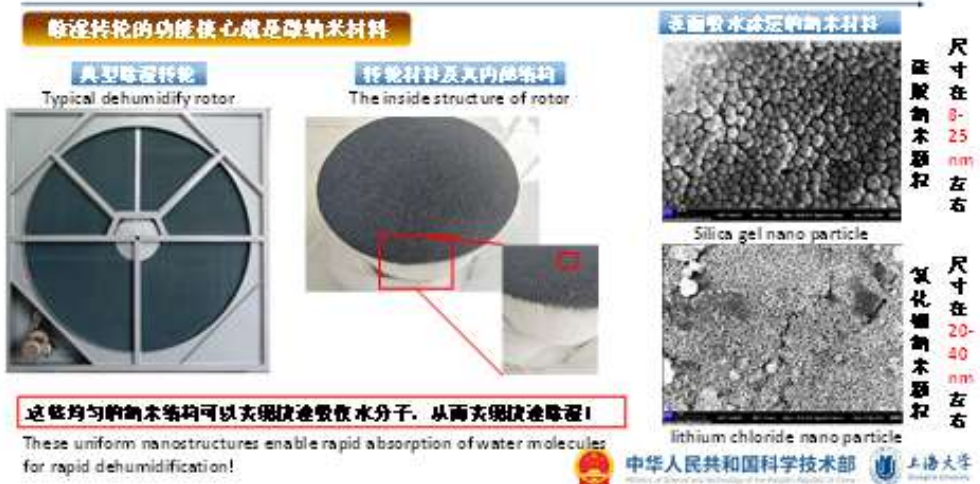


To achieve this demand, industrial environmental control equipment with dehumidifying wheels must be employed. Its basic principle is that the front end is a freezing dehumidification section, and the water above 5°C is removed as much as possible and then passes through the core wheel dehumidification section<sup>4</sup>.

<sup>4</sup> Yin *et al.* 2022.

The runner captures the moisture in the air through the super hydrophilic porous material and then discharges the moisture through the heating regeneration zone and regenerates the adsorption material<sup>5</sup>. The characteristic of this process is that all fresh air is treated, which requires stronger treatment capacity and stability.

### 除湿转轮除湿原理 Rotor dehumidification principle



The first type of nanomaterial is applied to the dehumidifying wheel, which is a typical shape of the dehumidifying wheel. The hygroscopic material is evenly distributed in the honeycomb of the material, and the coating on the surface is the core part of water absorption. Its micro-morphology is composed of hand-uniform nanoparticles. The holes formed by these nanostructures are the key structures for capturing water. Therefore, smaller and more uniform nanostructures are needed to absorb water more efficiently. At present, the highest level of Zeolite Wheel technology comes from Europe and Sweden. China has rapidly made significant progress in this field, narrowing the technological gap and successfully addressing critical bottlenecks that previously hindered domestic innovation.

I am currently engaged in collaborative research and development with Hanfu Qidong Environmental Technology Co., Ltd. to develop the advancement of desiccant wheel materials and manufacturing technologies, hoping to manufacture more energy-saving and lower-priced products. Hanfu Qidong Environmental Technology Co., Ltd – a professional manufacturer of industrial environmental control equipment – has a

5 DU *et al.* 2020; NORAZAM *et al.* 2019.

large scale and five branches. At present, its products are sold to more than 20 countries and regions all over the world and are recognized for their high quality and reliability, especially the dehumidifier for shipbuilding. The dehumidifier for shipbuilding is the only industrial environmental control equipment that can be used in LNG ship manufacturing in China at present. The lithium-ion dehumidifier produced by LNG vessels is one of the few dehumidifiers with fully welded boxes in the world. The quality and efficiency are not inferior to those of the products of Mouters Company in Europe, but the price is only half that of the other company.

Another category of micro-nano material to be introduced is a material used in the field of water environment restoration. In cases where rivers or lakes are subjected to prolonged pollution, the ecological balance of the waterbody is often severely disrupted, rendering natural self-recovery mechanisms ineffective. This is particularly true when the pollutants such as suspended solids (SS), nitrogen and phosphorus, exceed the standard, which can lead to eutrophication and, ultimately, malodorous and blackened water conditions. Under such circumstances, this kind of pollution can only be controlled by engineering restoration. Conventional engineering restoration technology improves the ecological environment by cleaning the riverbed, repairing the riverbank and planting plants. However, if the pollution cannot be cut off, the water quality will continue deteriorating, and the cost will become too high<sup>6</sup>.

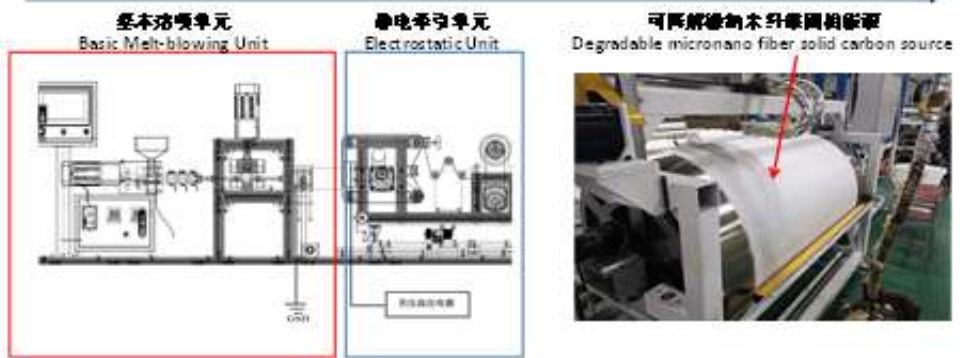
### 自然水体污染问题 Waterbody Pollution Problem



<sup>6</sup> PEILIN *et al.* 2019; MD ANAWAR *et al.* 2020.

The essential problem in the process of natural waterbody restoration is that there is not enough purification capacity. This deficiency primarily stems from an insufficient presence of functional microorganisms within the ecosystem<sup>7</sup>. If a structural medium could be introduced into the aquatic environment that effectively supports the enrichment and colonization of such microorganisms, it would allow for the continuous reduction of pollutant concentrations. The lack of food carbon sources and carrier for microorganisms is the micro-nano fiber solid carbon source carrier, which offer both a sustained carbon supply and a tailored support structure for microbial growth. The carrier is made by using this electrostatic melt-blowing technology, a process that may already be familiar (melt-blown fibers are widely used in the production of surgical masks, for example). Electrostatic melt-blowing is based on electrostatic traction, and a batch of stretched fibers are added to make them reach the micro-nano scale. In our approach, we employ the patented compound degradable polymer as raw material to prepare micro-nano fiber solid carbon source materials through electrostatic melt blowing.

### 静电熔喷技术 Electrostatic Melt-Blowing Technology



调配的可降解聚合物经上述熔喷和静电单元，被加工成均匀的微纳木纤维膜布  
 The compounded degradable polymer masterbatch is processed into a uniform micro-nano fiber membrane cloth through melt-blown and electrostatic units.



The size of this material is basically between 500 nm and 10 um. For context, the typical size of bacteria is between 450 nm and 2 um, which will produce a similarity distinct size effect<sup>8</sup>. Microorganisms will tend to accumulate in the interstitial spaces or junctions

<sup>7</sup> Qi *et al.* 2024.

<sup>8</sup> SINGH *et al.* 2021.

in the included angle of the fiber. Moreover, this material with secondary structure has a larger specific surface area, which can enrich more microorganisms. At the same time, the fiber will slowly release carbon sources to support the growth of microorganisms under the action of microbial enzymes. The fabrication of this material involves a range of design and processing parameters, which influence its final performance.

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## **FORUM 6**

**Coasts, Seas and Ocean**



## MARINE ECOSYSTEMS RESTORATION: AN OPPORTUNITY FOR A JOINT SINO-ITALIAN COOPERATION

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**Keywords:** ecosystem restoration, marine and coastal habitats

Marine and coastal habitat degradation is a topic of growing concern for both the Italian and Chinese governments. The decades following World War II witnessed a marked loss of marine habitats due to pollution and other anthropogenic drivers, leading to significant declines in biodiversity, ecosystem services, quality of life, and public health.

This issue affects not only the Mediterranean basin but also the South China Sea and the Yellow Sea. According to comprehensive scientific assessments, these regions share numerous environmental features and challenges: they are warm temperate, semi-enclosed seas (Mediterranean-type), characterized by intense anthropogenic pressures, habitat degradation, and the widespread introduction of alien species.

In response to these global threats to ecological integrity, the United Nations has declared the Decade on Ecosystem Restoration (2021-2030), aiming to restore both terrestrial and marine ecosystems and to achieve the target of protecting 30% of marine environments.

The European Union has been actively investing in this field, recognizing that strategies to combat marine degradation must go beyond pollution control and ecosystem protection. Restoration is also needed to compensate for the ecological damage caused by the development of offshore infrastructures such as ports, wind farms, mining platforms, and the extraction of polymetallic nodules from deep-sea environments.

Over the past two decades, ecological restoration science has advanced significantly, incorporating novel approaches and methodologies. While the importance of achieving a “Zero Pollution” target is widely acknowledged, it is equally crucial to consider the multiple factors that influence regenerative processes and shape effective marine policy. Restoration is no longer a secondary option but a strategic priority, which must complement conservation efforts and engage the global community and national governments alike.

Despite these developments, current efforts remain insufficient compared to the environmental degradation of the past seventy years, which has resulted in the loss of 30% to 80% of natural marine habitats, particularly in coastal zones.

It is important to emphasize that ecosystem restoration is not only a method for conserving biodiversity but also a driver of technological innovation and economic opportunity. Successful marine restoration depends on the coordinated involvement of:

1. Governments, through the establishment of laws (e.g., the EU Nature Restoration Law), regulations, and dedicated investments;
2. Private stakeholders, as the main actors in implementation;
3. The scientific community, which provides the expertise, tools, and monitoring frameworks required for effective intervention.

The socioeconomic potential of restoration efforts is key to citizen engagement and financing. Although marine restoration is a comparatively young discipline relative to its terrestrial counterpart, findings from the last thirty years demonstrate its efficacy. Restoration is feasible and highly successful across a range of critical habitats – including seagrass meadows, macroalgal and gorgonian forests, mangroves, coral reefs, and more – even in polluted environments.

Thus, marine ecosystem restoration is increasingly regarded as a robust nature-based solution that not only enhances biodiversity but also contributes to ecosystem clean-up. For example, restoring oyster beds not only promotes marine biodiversity but also facilitates carbon sequestration, water filtration, and nutrient removal.

Moreover, studies report that the economic return from restoration activities can be 10 to 40 times higher than the initial investment, with positive returns often emerging within the first three years. In this sense, investing in marine ecosystem restoration is a high-benefit, low-risk strategy.

The United Nations is currently engaged in several large-scale marine restoration programs, particularly in mangrove and macroalgae ecosystems, which are considered global priorities. Italian scientists are also contributing to restoration initiatives worldwide – from coral reefs in Singapore and China to the Red Sea and the Arabian Peninsula – often in alignment with industrial developments led by major Italian energy companies.

At the European level, Italy holds a leading position in the field of marine ecological restoration. Since 2015, it has coordinated major EU projects in this area. One prominent example is the REDRESS project (Restoration of Deep-Sea Habitats to Rebuild European Seas; <https://redress-project.eu/>), which exemplifies the technological and ecological ambition of this emerging discipline. Italy is now well-positioned to pursue a joint scientific and technological pathway with China, aimed at enhancing the effectiveness and scalability of marine ecosystem regeneration.

## NEW OPPORTUNITIES FOR CHINA-ITALY MARINE SCIENCE AND TECHNOLOGY COOPERATION UNDER THE MARITIME COMMUNITY WITH A SHARED FUTURE

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**Keywords:** scientific research, international cooperation, marine development, coastal protection

In July and November this year 2024, Italian Prime Minister Giorgio Meloni and President Sergio Mattarella visited China successively. The President Xi Jinping had cordial talks with them and drew a blueprint for the future development of China-Italy relations. Chinese and Italian universities have carried out extensive academic and youth exchanges, deepened scientific research cooperation and expanded joint research in emerging disciplines. To commemorate Marco Polo's 700<sup>th</sup> anniversary of his passing, the library of Zhejiang Ocean University held a memorial exhibition of Marco Polo's eastward journey<sup>1</sup>. From the perspective of the community of marine destiny, the all-round cooperation between the two countries in the marine field will help to promote China-Italy cooperation in marine education and scientific research, build a platform for interactive cooperation between the Mediterranean and the East China Sea, and work together for the coordinated development of production and life ecology in the urbanized waters.

With the leadership and support of central and local governments, Zhejiang Ocean University has cooperated with the University of Pisa in Italy since 2015 and established Pisa Marine Graduate School in 2019. After nearly 10 years of communication and cooperation, it has made a series of important achievements in personnel training, academic exchanges, scientific research and platform construction. In terms of personnel training and education, a total of 6 doctoral students and 273 Chinese Italian dual-degree postgraduate students were jointly trained, involved in marine science, and food processing and safety. By holding the normalized China-Italy workshop Conference with the theme of "Application of Scientific Research and Higher Education in the Marine Field" and the

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<sup>1</sup> "Visit the exhibition and get a gift! The library invites you to embark on Marco Polo's journey to China" (2024-09-30) <https://mp.weixin.qq.com/s/w8Z7RpDOcdUMbYu0DJ4psA>.

normalized International Forum for Presidents of Marine Universities with the theme of “Deep Cultivation of the Ocean, Drawing Future and Open Sharing”, the cooperation and exchanges in the field of marine science and technology have been greatly promoted.

This year, Zhejiang Ocean University was successfully approved by the United Nations Decade of Ocean Science project “Seafood Fishery Resource Ecosystem Engineering”, and the cooperation of aquatic food cold chain logistics and preservation equipment was also included in the 12<sup>th</sup> China-Italy Science, Technology and Innovation Week. In 2020, Zhejiang Ocean University was successfully approved by the International Cooperation and Exchange of the National Natural Science Foundation of China (42020104009), “Discovery and Mining of Immunity Uniqueness of Marine Mussel for Environmental Adaption”. Relying on the international joint projects, we held the 1<sup>st</sup> International Academic Conference on Mussels Biodiversity<sup>2</sup>, Sustainable Utilization and Protection, and have published more than 100 related academic papers. In terms of platform construction, Zhejiang Ocean University, together with the University of Pisa and the Italian Institute for Environmental Protection and Research (ISPRA), has declared and approved the provincial international joint laboratory “Sino-Italian Joint Laboratory of Functional Biology of Marine Biota”<sup>3</sup>. Dr. Zhou Chao and Dr. He Jianyu, who were jointly trained by our university and Italian universities, combined two species *Mytilus galloprovincialis* and *Mytilus coruscus*, and promoted the research on the environmental adaptation and ecological contribution of shellfish in the international cooperation project, which is a typical representative of the internationalization of school education and scientific research.

By exploring the survival and adaptation mechanisms of *M. galloprovincialis* and *M. coruscus* in response to the marine pathogenic bacteria, we observed that the mussels contain many antibacterial peptides (AMPs), including AMPs with similar structures to those from arthropods<sup>4</sup>. Which indicates an evolutionary relationship between molluscs and arthropods AMPs. In addition, histone-derived AMPs, an AMP family that had been considered as belonging to vertebrates specifically, were also detected from *Mytilus*<sup>5</sup>. These histone-derived AMPs can be activated and generated quickly in *Mytilus* after bacteria challenge, thus showing important roles in *Mytilus* immunity<sup>6</sup>. Our observations

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<sup>2</sup> Zhejiang Ocean University “Approved for International Joint Laboratory in Zhejiang Province” (2024-12-13) <https://news.zjou.edu.cn/info/1141/60929.htm>.

<sup>3</sup> The university successfully organized “The 1st International Academic Conference on Mussel Biodiversity, Sustainable Utilization and Protection” (2022-05-09) <https://news.zjou.edu.cn/info/1037/54510.htm>.

<sup>4</sup> YANG, HE, LIU *et al.* 2022; LIU, HE, YANG *et al.* 2022, 817-826.

<sup>5</sup> WANG, LIAO, YANG *et al.* 2024.

<sup>6</sup> YANG, HE, LIU *et al.* 2022; HE, HE, WANG *et al.* 2022; PAN, LIAO, HE *et al.* 2022, 1121-1134.

revealed the possible biochemical mechanisms of mussels in their excellent environmental adaptability and provided a scientific basis for the cultivation of mussels in urbanized waters and the further expansion of ecological value.

A variety of microbes coexist in the tissues of mussels, forming a unique micro-ecology<sup>7</sup>. How does the ecological association between mussels and tissue-scaled microbiota affect the surrounding environment as well as the marine carbon sink? To address the knowledge gaps, we have further studied the microbial community structure and carbon cycle in mussel farming zones<sup>8</sup>. We found that the impacts of mussel aquaculture on the surrounding sea are multidimensional and then proposed a “Mussels-Microalgae-Microbiota (3M)”- based consortium modelling for sink enhancement<sup>9</sup>. In this scheme, phytoplankton absorbs carbon dioxide from the air and maintain the primary productivity of the ocean; filter-feeding shellfish, like a pump, accelerate the turnover of algae and the downward deposition of algae-derived carbon by feeding, and further converts activated carbon into recalcitrant carbon<sup>10</sup>, thus expanding the contributions of mariculture carbon sink and helping the global marine blue carbon research.

Based on the above research, we advocate re-evaluating the ecological value of mariculture, especially shellfish culture, elucidating the blue carbon contribution, aligning the ecosystem services, and establishing a novel calibration of carbon sink measurement. Relying on the global distribution characteristics of shellfish, we hereby propose to launch the mussel watch v3.0 plan based on ecological assessment. This plan mainly focuses on the ecological indicative value of shellfish, re-examines its ecological distribution characteristics, and provides a new model for solving the global climate change problem.

The president Xi pointed that building a maritime power is an important component of the cause of socialism with Chinese characteristics and we should pay more attention to making greater achievements in the construction of a maritime power by learning about and utilizing marine resources. It is important to insist on the coordinated land and marine development, and to adhere to the development path of “enriching the country by relying on the sea, strengthening the country with the sea, achieving harmony between people and the sea, and win-win cooperation”. How to persist in the land-sea coordination and land-based sea, and systematically handle the relationship between the sea and the city? This is a major scene of the development and communication of world civilization. Industry, living, and ecology are the three main scenarios, and the balanced development based on cross-disciplinary scientific research is the key to make solution for the future. To make

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<sup>7</sup> HE, JIA, WANG *et al.* 2023; MUSELLA, WATHSALA, TAVELLA *et al.* 2020; LI, CHEN, XU *et al.* 2019.

<sup>8</sup> PAN, LIAO, HE *et al.* 2022, 1121-1134; LI, CHEN, XU *et al.* 2019.

<sup>9</sup> HE, TAO, SHAO *et al.* 2024; HE, ZHU, YAN 2025.

<sup>10</sup> HE, ZHU, YAN 2025.

these come true, we hope to unite Chinese and Italian universities and institutions to develop the emerging discipline of Urbanized Ocean Science (The Science for Urbanized Ocean). Relying on the naval architecture and marine engineering to solve the problems of port function and industrial development in cities, relying on the marine aquaculture to provide high-quality seafood, and relying on marine science to manage urban and marine habitats, so as to achieve harmonious coexistence between man and nature. This discipline is a high integration of high-quality development, high-quality life and high-efficiency governance, which injects new impetus into marine scientific and technological innovation in Mediterranean economies and the Yangtze River Delta Economic Belt.

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## Sitography

- “Visit the exhibition and get a gift! The library invites you to embark on Marco Polo’s journey to China” (2024-09-30) <<https://mp.weixin.qq.com/s/w8Z7RpDOcdUMbYu0DJ4psA>>.
- “Zhejiang Ocean University was approved as Zhejiang Province International Joint Laboratory” (2024-12-13) <<https://news.zjou.edu.cn/info/1141/60929.htm>>.
- “The school successfully held the first international academic conference on mussel biodiversity, sustainable use and conservation” (2022-05-09) <<https://news.zjou.edu.cn/info/1037/54510.htm>>.



# XENOBIOTICS, ALIEN SPECIES AND PATHOGENS: INSIDIOUS IMPACTS ON REPRODUCTIVE PATTERNS OF MARINE ORGANISM

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**Keywords:** reproductive behavior, man-induced effects, introduced species, imposex, diseases

## 1. Introduction

Reproductive strategies maximize fitness and vary with environmental conditions<sup>1</sup>. Tactics include sex ratio manipulation and sex change in hermaphrodites<sup>2</sup>.

External fertilization produces many offspring but low survival, while post-fertilization strategies include lecithotrophic or planktotrophic larvae.

Parental care improves offspring survival<sup>3</sup>. Species differ in reproductive frequency: semelparous reproduce once, iteroparous multiple times<sup>4</sup>.

Environmental stressors, especially anthropogenic ones, reduce fertility, delay maturation, and disrupt reproductive success, impacting genetic structure and population viability<sup>5</sup>.

## 2. Endocrine-active chemicals

Endocrine disruptors (EDs), including legacy chemicals (e.g., PCBs, organochlorine pesticides) and some modern compounds (e.g., plasticizers, surfactants), negatively affect human and wildlife health.

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<sup>1</sup> STEARNS 1992; FLEMING 1996, 379-416.

<sup>2</sup> COLE, SHAPIRO 1995, 65-75.

<sup>3</sup> FERNÁNDEZ *et al.* 2000, 487-494.

<sup>4</sup> BOLETZKY 1986, 379-389.

<sup>5</sup> SCHRECK 2000; POTTINGER, PICKERING 1990, 264-273; CAMPBELL *et al.* 1992, 1140-1150 SCHRECK *et al.* 2001, 3-24.

Many EDs bioaccumulate and biomagnify in marine food webs due to their persistence and lipophilicity. While most research focuses on fish<sup>6</sup>, invertebrates remain understudied despite their ecological importance.

A key example is imposex in marine gastropods caused by tributyltin (TBT), a banned antifouling agent. TBT elevates androgen levels, causing male traits to develop in females across over 100 species<sup>7</sup>, even in Marine Protected Areas<sup>8</sup>.

In some species, reproduction is unaffected<sup>9</sup>, while in others, TBT leads to sterility, population decline, or local extinction<sup>10</sup>.

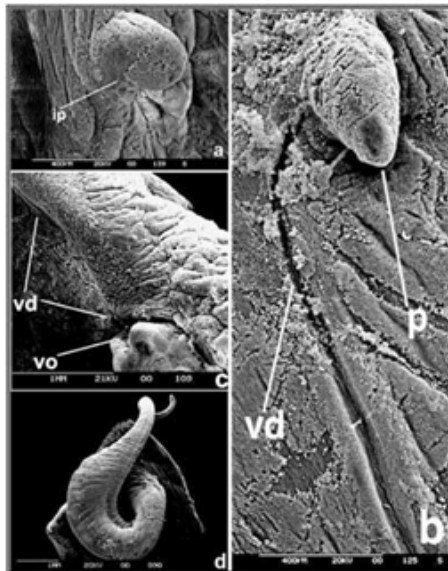


Fig. 1. *Hexaplex trunculus*. SEM photographs of (a) stage 1, presence of an incipient penis (ip); (b) stage 3, presence of a penis (p) with a well-developed vas deferens (vd); (c) stage 4, vas deferens reaching vaginal opening (vo); (d) penis in a female (shell length 61.3 mm) at a 4 stage of imposex (modified from).

<sup>6</sup> ROTCHELL, OSTRANDER 2003, 453-495.

<sup>7</sup> SPOONER *et al.* 1991, 37-49; FIORONI *et al.* 1991, 1-26.

<sup>8</sup> TERLIZZI *et al.* 2004, 109-117.

<sup>9</sup> GIBBS *et al.* 1991, 231-235.

<sup>10</sup> TEN HALLERS-TJABES *et al.* 1996, 333-343.

### 3. Impact of algal metabolites on the reproductive potential of native species

The introduction of alien species can disrupt ecosystems by altering environmental conditions and affecting native species' growth, reproduction, and survival. Hybridization with native species can reduce genetic diversity and lead to sterile offspring, increasing extinction risk<sup>11</sup>.

A less explored impact is the role of secondary metabolites from alien species. Native fauna, lacking evolutionary defenses, can suffer severe effects. For instance, toxic algal blooms have caused mass die-offs and reproductive failures across species, affecting ecosystem balance<sup>12</sup>.

A key case is the invasion of *Caulerpa cylindracea* in the Mediterranean. Its spread in shallow habitats is partly due to bioactive compounds that aid competition<sup>13</sup>. Notably, the native fish *Diplodus sargus* now consumes large amounts of this alga<sup>14</sup>.



Fig. 2. Adult specimen of *Diplodus sargus* grazing on the rocky bottom with low coverage percentages of *Caulerpa racemosa* (photo by G. Guarnieri).

<sup>11</sup> MACK *et al.* 2000, 689-710; PIMENTEL *et al.* 2005, 273-288; BYRNES *et al.* 2007, e295.

<sup>12</sup> MIRALTO *et al.* 1999, 173-176.

<sup>13</sup> RANIELLO *et al.* 2007, 361-368.

<sup>14</sup> TERLIZZI *et al.* 2011.

*Diplodus sargus* feeding on *Caulerpa racemosa* accumulates caulerpine, an algal alkaloid, with tissue-specific concentrations – highest in brain, red muscle, and liver. Ecotoxicological studies showed altered antioxidant defenses, induction of cytochrome P450, and increased hepatosomatic index. A decrease in gonadosomatic index (GSI), an indicator of reproductive condition, was also found. The inverse correlation between GSI and caulerpine suggests impacts on gonadal development. Similar GSI reductions occur with endocrine disruptors like 17 $\beta$ -estradiol<sup>15</sup>, leading to sperm count declines<sup>16</sup>. Cytochrome P450 activity in the liver also correlates negatively with egg viability and embryonic success<sup>17</sup>, implying interference with sex steroid regulation. These findings suggest that the spread of *C. racemosa* in the Mediterranean may alter fish feeding behavior and impair reproduction through its metabolites<sup>18</sup>.

#### 4. Pathogens

Emerging infectious diseases threaten marine ecosystems, contributing to fish stock declines alongside habitat destruction and overfishing<sup>19</sup>. Pathogens affect survival, behavior, growth, and reproduction, influencing population dynamics<sup>20</sup>.

These diseases can impair reproduction, as seen with Yellow Band Disease in *Montastraea faveolata* due to *Vibrio* infections<sup>21</sup> and aspergillosis in *Gorgonia ventalina*<sup>22</sup>.

In fish, Viral Encephaloretinopathy (ERV) causes high mortality and reduced hatching success, raising concerns for population viability, especially in Marine Protected Areas (Fig. 3)<sup>23</sup>.

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<sup>15</sup> BJERSELIUS *et al.* 2001, 139-152; CHANG and LIN 1998, 165-173.

<sup>16</sup> BAATRAP, JUNGE 2001, 1063-1070.

<sup>17</sup> VAN DER OOST *et al.* 2003, 57-149.

<sup>18</sup> FELLINE *et al.* 2012, e38763.

<sup>19</sup> GOZLAN *et al.* 2005, 1046.

<sup>20</sup> HARVELL *et al.* 2004, 375-382.

<sup>21</sup> WEIL *et al.* 2009, 45-55.

<sup>22</sup> KIM, HARVELL 2004, S52-S63; BEIRING, LASKER 2000, 169-177; PETES *et al.* 2003, 167-171.

<sup>23</sup> MUNDAY *et al.* 2002, 127-142; BOVO *et al.* 1999, 143-146; MUSHIAKE *et al.* 1994, 177-182; TERLIZZI *et al.* 2012, 403-414.



Fig. 3. Dead adult specimen of *E. marginatus* on the bottom as a consequence of Viral Encephalopathy and Retinopathy (VER) infection (photo by P. Patarnello).

Parasites can reduce fertility by altering host physiology, energy, use, behavior, and sex ratios<sup>24</sup>. Some act as castrators, redirecting energy from reproduction to survival<sup>25</sup>, leading to major reproductive declines<sup>26</sup>.

Castration is common in invertebrates (e.g., trematodes in gastropods), but rarer in fish (e.g., parasitic copepods and isopods like *Anilocra apogonae*<sup>27</sup>). Parasites may also alter mating behavior – for example, female sticklebacks avoid infected males<sup>28</sup>, and parasitized damselfish lose more eggs<sup>29</sup>. Some species respond by maturing earlier in parasite-rich settings<sup>30</sup>. Human activities and climate change are amplifying parasite impacts and spreading pathogens<sup>31</sup>.

<sup>24</sup> GULLAND 1995, 20-51; ALKER *et al.* 2004, 397-405.

<sup>25</sup> BAUDOIN 1975, 335-352; HECHINGER *et al.* 2009, 651-667.

<sup>26</sup> LAFFERTY 1991, 3-11; KURIS, LAFFERTY 1992, 327-336.

<sup>27</sup> FOGELMAN *et al.* 2009, 577-583.

<sup>28</sup> MILINSKI, BAKKER 1990, 330-333.

<sup>29</sup> SASAL 2006, 1215-1221.

<sup>30</sup> LAFFERTY 1993, 3-11.

<sup>31</sup> NAYLOR *et al.* 2005, 427-437; GOZLAN *et al.* 2006, 1046.

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# DEVELOPMENT OF WOUND DRESSINGS USING MARINE BIOMATERIALS

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**Keywords:** research, clinical applications, key technologies, photopolymerization hydrogel, cartilage repair, transplant rejection, tissue repair, alternative materials, acellular fish

## 1. Wenzhou and Italy exchanges

I come from Wenzhou, a seaside city in the east of China. It's an hour's flight time and about 2 hours by high-speed rail from Shanghai. Wenzhou people, with the reputation of Oriental Jews. At present, there are about 200,000 Wenzhou people mainly engaged in business activities in Italy. Italy is the first place for early Wenzhou people to stay overseas. Italy has many Wenzhou tastes, and Wenzhou also has the flavor of Italy. In Wenzhou, there is a restaurant called Luofeike, which was operated in Wenzhou after an Italian chef married a local girl in Wenzhou. At present, it has a history of nearly 20 years, with authentic taste and constant customers. Our family all likes this restaurant. What's more commendable is that Wenzhou as a small and medium-sized city, has direct flights to Rome and Milan, which is enough to show close exchanges between Wenzhou and Italy.

## 2. Wenzhou Institute, UCAS

The orientation of the Institute is to strengthen research on clinical applications and key technologies, promote the innovation of system and mechanisms, become a model of industry-university cooperation, and promote the development of Wenzhou biomedical industry. The institute mainly focuses on medical biomaterials, high-end medical equipment, biomedical physics and other directions, serving the national strategic needs and empowering local development. There are 20 people in our team, including 5 doctoral researchers, 2 postdoctoral researchers and 9 doctoral and master students.

Science knows no borders, and we are willing to communicate and cooperate with international scholars to explore the frontier of science and technology. In recent years, I have also visited Europe many times, visiting and studying in Britain, Germany and Poland. I have been selected for the China-Japan Sakura Science Exchange Program of the Ministry

of Science and Technology and the China-Australia Young Scientists Exchange Program. My research focuses on tissue engineering, nanomedicine and biological interface. Up to now, more than 60 SCI papers have been published, with H factor of 30. At the present, I am in charge of projects such as the Ministry of Science and Technology, the National Natural Science Foundation of China and the Chinese Academy of Sciences, with a total fund of more than 10 million RMB.

### **3. Transplant rejection, tissue repair and alternative materials to solve clinical application**

Tissue repair materials have great clinical application needs. At present, the commonly used autologous materials have some problems such as scarce supply sources. The same applies to synthetic biomaterials, such as lack of bioactivity, and heterogeneous tissue engineering materials are the most potential ways to solve these problems. The main source of heterogeneous tissue engineering materials is animals, and the extracellular biological activity can be retained by acellular treatment.

We chose cloned pigs and tilapia. The organ sizes of pigs and people are very close, and the breeding of fish is fast and large, which is easy to industrialize. We focused on the research and development of key technologies of biomaterial products in heterogeneous organizations and achieved a series of key achievements.

The first part introduces the application of heterogeneous tissue engineering materials in bone repair. At first, we established a heterogeneous acellular composite with low immunogenicity, which was prepared by acellular pig as donor, ultra-low temperature processing, and then mixed with polymer or protein-based hydrogel. Then we combined with biological 3D printing to prepare porous scaffold for skull defect repair, and adding 35% bone powder can promote bone repair. When we use protein-based hydrogel GelMA instead of high molecular material PCL, this photopolymerization hydrogel system can achieve better bone repair effects in 12 weeks.

The second part is the application of heterogeneous tissue engineering in cartilage repair. Firstly, according to the extracellular matrix of human cartilage tissue, we constructed an injectable hydrogel composite system with low immunogenicity. We found that the injectable hydrogel composite had a good repair effect after 9 weeks.

Recently, we have also carried out research on heterogeneous tissue engineering materials for skin repair. This work is mainly based on two news stories a few years ago, the kitchen fire in Brazil in 2016, which caused the chef to be burned; In 2017, a forest fire in California, USA, caused bears to be burned. They simply clean the fish skin and stick it on the wound surface, which has a good repair effect.

A company in Iceland has developed acellular fish skin dressing based on Atlantic cod skin. After acellular treatment, cod skin is added with growth factors, which can be used to repair diabetic wounds.

Our research group made some preliminary attempts on acellular tilapia skin in the early stage, and obtained acellular fish skin by chemical acellular method, which was used to repair skull defects. Later, the method of acellular fish skin was optimized, and the chemical residue was reduced by physical methods, and then the physical and chemical properties of electro-acellular fish skin were characterized.

We evaluated the effects of different decellularization technologies on the physical and chemical properties of materials and found that the decellularization effect was the best under the action of electric field. After decellularization, most of the collagen, elastin and polysaccharide can be retained, and the water vapor permeability can also meet the requirements of pharmaceutical industry characterization.

We standardized the microstructure of acellular fish skin and found that physical acellular fish skin would not destroy the internal structure. We also standardized the cytotoxicity, hemolysis, degradability and immunogenicity of acellular fish skin.

Using different methods, we can see that the immunogenicity of acellular fish skin is relatively low. We also verified it on the mouse wound model and found that the dermal fish skin and wound repair can complete the composite of the wound within 14 days.

Next step, we will continue to explore acellular fish skin heterogeneous tissue engineering materials according to the previous experimental progress and provide technical sources for domestic substitution of high-end medical devices. In the aspect of skin repair, the biosafety assessment of acellular fish skin was completed, and the quality inspection of acellular fish skin and the application for clinical trial license were initiated. In the end, what we have to do is to develop tissue repair engineering products that the people need.

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## THE SINO-ITALIAN JOINT LABORATORY “FUNCTIONAL BIOLOGY OF MARINE BIOTA” 15 YEARS OF COLLABORATION BETWEEN ISPRA AND ZJOU

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**Keywords:** environmental protection, marine ecosystems, biodiversity, marine biota, ecotoxicological approach, plankton biology, future evolutionary scenarios

The Italian Institute for Environmental Protection and Research (ISPRA) is a public research centre supervised by the Ministry of the Environment and Energy Security and, together with the 21 Regional Environmental Protection Agencies, forms the National Environmental Protection Network System. The activity is related to the monitoring, control and legislative support on environmental issues concerning freshwater and sea, air, soil and subsoil. ISPRA is present throughout the country, with laboratories and main center in Rome other than in other regions, such as Veneto, Emilia-Romagna, Tuscany and Sicily. In particular, in Tuscany, the activity of the Section for Ecological Risk Assessment in Marine-Coastal Areas of the National Centre for Environmental Characterisation, Coastal Zone Protection, Marine Climatology and Operational Oceanography in Livorno, are focused on research and monitoring of marine-coastal ecosystem. More specifically, activities concern the following topics: development of innovative technologies and protocols for reproduction of marine organisms to be used as model organisms. In this context, ISPRA, with the Functional Biology and Plankton Genomic Lab. is the lead partner in the Italy-France maritime Interreg project AQuaBioS, which is focused on the study of marine planktonic organisms reproduction to use in aquaculture and as model organisms for marine research. A second topic is focused on monitoring activity of marine-coastal ecosystem, to define environmental quality through an integrated chemical-physical and ecotoxicological approach. A third topic concerns the research of innovative technologies for the environmental remediation of contaminated marine matrices. Experimental approach for the reuse of marine sediments is developed in the Euromed-funded project TREASURE.

The collaboration between Zhejiang Ocean University (ZJOU) and the Italian Institute for Environmental Protection and Research (ISPRA) began more than 15 years ago and was initially focused on research regarding aquaculture implementation techniques,

through the innovative cultivation of marine copepods (zooplankton) to be used as live food for fish larvae. Over time, an intensive exchange of visits took place between researchers and students from both research institutes, with the aim to share experiences and to strengthen the collaboration. Main research topics were focused on plankton biology, physiology and ecotoxicology. Both parties hosted PhD students, in collaboration with Italian Universities such as the University of Naples Federico II and the University of Pisa.

As a natural consequence of this fruitful collaboration, the new Memorandum of Understanding, signed between ISPRA and ZJOU, sanctioned the intention to establish the Sino-Italian Joint Laboratory “Functional Biology of Marine Biota”.

After the long pause due to the pandemic, ISPRA together with the Italian Embassy in Beijing, the ZJOU, the Anton Dohrn Zoological Station in Naples and the University of Pisa organised the First Italy-China Bilateral Workshop on Scientific and Technological Research and Higher Education applied to Marine Sciences. On this occasion, the agreement for the establishment of the joint ISPRA-ZJOU laboratory was signed.

Two years later, in 2024, within the Second Bilateral Workshop on Scientific and Technological Research and Higher Education applied to Marine Sciences, organised in China by ZJOU, the joint laboratory “Functional Biology of Marine Biota” was then inaugurated.

The aim of the joint Sino-Italian Lab. is to focus bilateral research on the study of biology and genomics of marine model organisms in relation to environmental changes. The ‘omics’ approach favours to link functional and biological processes with anthropogenic pressures occurring in marine ecosystems. By integrating investigations that include metabolomics, transcriptomics, the study of immune responses and microbial biodiversity, with climate variations, ocean acidification and interactions between trophic networks, we can obtain information on what will be the future evolutionary scenarios of marine ecosystems, both in the Mediterranean and in the oceans. The results are useful for decision-makers to address future actions necessary for the conservation of marine ecosystems and biodiversity.

This collaboration has produced some very interesting results and numerous publications in recent years, and we are confident that this collaboration will continue and will be able to involve other scientific organisations to address the challenges of the coming years for the conservation of marine ecosystems and a common vision of scientific research on the sea.

## ASSESSMENT AND RESPONSE TO MICROPLASTIC POLLUTION ON MARINE ECOLOGICAL ENVIRONMENT AT THE “CORAL TRIANGLE” REGION

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**Keywords:** innovative programs, microplastic pollution, coral triangle, maritime silk road, cooperation

ANSO is short for the “Alliance of National and International Science Organizations for the Belt and Road Regions”. ANSO is a non-profit and non-government international scientific organization founded in 2018 by the Chinese Academy of Sciences (CAS) and 36 scientific organizations worldwide. The establishment of ANSO was warmly and immediately congratulated on by His Excellency Chinese President Xi Jinping. The vision of ANSO is to become an international science organization of global impact in catalyzing and implementing concrete innovative programs, initiatives and actions in Science, Technology, Innovation and Capacity Building (STIC) for the promotion of shared-development and the advancement of the UN Sustainable Development Goals (SDGs).

ANSO members are from national academies of sciences, universities, research institutes and international organizations. ANSO is committed to playing an effective role in catalyzing and implementing innovative international science initiatives with the member countries and other partners to advance the ANSO vision and help build a community of the whole humankind with a shared future. Science, Technology, Innovation and Capacity building (STIC) is essential to the progress and welfare of human societies and ANSO is particularly keen to cooperate and partner those who want to collaborate in these endeavors.

ANSO has four different programs, which are CAS-ANSO science programs, CAS-ANSO Scholarship, CAS-ANSO fellowship and CAS-ANSO conference. And this program “Assessment and Response to Microplastic Pollution on Marine Ecological Environment at the “Coral Triangle” Region” (Microplastic program) is the one from the CAS-ANSO science programs with multi-lateral collaborations from 4 countries.

In April 2023, this program was officially launched at the Campus of Research Center for Oceanography -National Research and Innovation Agency (RCO-BRIN) in Jakarta, Indonesia. Ten researchers from four countries made illuminating reports, and more than 50 researchers participated in the launch meeting. In July, the Sina-Indonesia

Joint Laboratory for Marine Science (SIMS) was officially put into operation to support and assist the development of scientific research on both sides. In November, the two sides successfully carried out the China-Indonesia joint cruise IMPOLSE 2023, which was the first large-scale joint cruise in Indonesian seas after and pandemic and reform of the new BRIN.

In June 2024, Indonesian microplastics expert M. Reza Cordova worked at Qingdao for 3 months as an ANSO visiting scientist, conducted plenty of academic exchanges with Chinese researchers, guided graduate students and formulated cruise sampling plans. The two sides added 1 new scientific research project, carried out 1 training of latent mark technology, jointly published 5 microplastics SCI academic papers, and supervised 6 graduate students. The project has carried out isolation and cultivation of marine microorganisms degrading polyurethane and other plastics and preliminarily clarified the mechanism and specific pathway of the degradation of polyurethane plastics by marine fungi in deep sea.

The “Coral Triangle” refers to the more than 6 million square kilometers of triangular sea area between Indonesia, the Philippines and Papua New Guinea. It is an important area for us to implement the 21st century “Maritime Silk Road” strategy. It is also the global center of marine biodiversity, home to 370 million people who depend on marine ecosystems for their livelihoods and food sources. It is also the area with the most serious microplastic pollution in the world. Limited by economic and scientific research conditions, large-scale and systematic basic surveys of marine microplastic pollution and influence on the ecology have not yet been carried out. Hence, the Institute of Oceanology, Chinese Academy of Sciences, together with the Indonesian Research Center for Oceanography, the University of the Philippines, the University of Papua New Guinea and other scientific research institutions, carried out a comprehensive survey in the “Coral Triangle” sea area to systematically analyze the current distribution and changing trends of marine microplastic pollution in this area. The in-situ measurement and research provide a scientific basis for the local government to grasp the distribution and pollution level of microplastics in their territory. By studying the quantity and shape characteristics of microplastics in representative fish and shellfish in this area, the potential impact of microplastics on the biological safety of marine fish and shellfish is revealed, and a theoretical basis is provided for ensuring the food and biological security of neighboring countries. By isolating microbial strains, screening microorganisms that can effectively degrade plastic particles, and obtaining high-degradation activity “enzyme weapons” to reduce plastics, promote industrial application demonstrations, and provide technical support and solutions for the prevention and control of microplastic pollution in the region. The implementation of this project will effectively promote the improvement of the scientific research capabilities of the Belt and Road countries, expand the cooperation network with the leading maritime powers in Southeast Asia, and significantly enhance the international influence of ANSO.

**FORUM 7**

**Polar Sciences**



## POLAR SCIENCES

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**Keywords:** polar research collaboration, arctic and Antarctic climate studies, polar sciences, marine ecosystem monitoring, ross sea marine protected area

The Polar Sciences session of the 2024 Italy-China Science and Innovation Week provided a valuable platform for discussions on strengthening scientific cooperation between Italy and China in polar research. The session brought together experts from both nations to explore opportunities for joint initiatives, particularly through a proposed Memorandum of Understanding (MoU) between the Polar Research Institute of China (PRIC) and the Institute of Polar Sciences of the Italian National Research Council (ISP-CNR).

This proposed agreement would serve as a framework for enhancing collaboration, optimizing the use of shared resources, and improving the efficiency of research infrastructure in the Arctic and Antarctic regions. The session underscored the need for coordinated efforts in scientific studies, logistical support, and the conservation of fragile polar ecosystems.

The first talk highlighted the extensive geological research conducted in Antarctica, with a focus on the Hughes Bluff granitic pluton in the Transantarctic Mountains. This study, presented by Chinese researchers, provided insights into the geochemical and petrological characteristics of the region, emphasizing the potential for joint geological surveys and data-sharing between Italian and Chinese research teams.

A retrospective on Italy's National Antarctic Research Program (PNRA) celebrated four decades of scientific achievements in Antarctica has been presented. Italy has played a key role in Antarctic research, with Mario Zucchelli Station and the Franco-Italian Concordia Station serving as strategic hubs for climate, atmospheric, and glaciological studies. The Beyond EPICA project, a European-led initiative coordinated by Italy, was also discussed as a critical contribution to understanding past climate variations.

Studies presented by Italian oceanographers, explored the formation of Antarctic Bottom Water (AABW) in the Ross Sea, a crucial process influencing global ocean circulation, carbon sequestration, and climate stability. Given the increasing environmental pressures on Antarctic waters, bilateral research collaboration was deemed essential to monitor climate trends and preserve the marine ecosystem.

Another presentation showcased China's expertise in marine remote sensing and AI-based ocean monitoring, particularly through the work of the Second Institute of Oceanography (SIO). Chinese researchers presented advanced four-dimensional ocean observation systems, which utilize satellite data, in-situ measurements, and AI models to track oceanic changes, pollution, and marine biodiversity. These technological advancements present an opportunity for Italy and China to collaborate on long-term marine monitoring projects.

Italian research in the Arctic cryosphere was another key topic of discussion. Italy's Arctic Station "Dirigibile Italia", located in Ny-Ålesund (Svalbard), was presented as a crucial research facility for studying climate change, atmospheric dynamics, and permafrost stability. Italian scientists emphasized the role of Arctic amplification – the phenomenon where the Arctic warms at twice the global average rate – and how long-term monitoring at Svalbard is essential for understanding these changes.

From the Chinese perspective, researchers presented studies on Arctic permafrost degradation and its implications for biogeochemical cycles. The rapid thawing of permafrost is releasing stored carbon, heavy metals, and microplastics into Arctic ecosystems, with potential impacts on global climate feedback loops. Collaborative efforts between Italy and China in cryospheric monitoring and pollution tracking were identified as essential priorities.

A particularly insightful presentation focused on glacier melting and its consequences for downstream ecosystems, with case studies from the Tibetan Plateau. The discussion drew parallels between high-mountain and polar glaciers, highlighting concerns about increased microbial activity, greenhouse gas emissions, and potential health risks as glaciers continue to retreat. The presence of pathogenic bacteria and antibiotic-resistant genes in glacial meltwater raises public health concerns, emphasizing the need for long-term monitoring and international cooperation.

One of the major themes of the session was the conservation of the Ross Sea Marine Protected Area (MPA), the world's largest marine reserve, covering 1.55 million square kilometers. Both Italy and China operate research stations in this critical region, making them key stakeholders in its protection. The discussion emphasized that the two nations should act as guardians of the Ross Sea, ensuring that scientific research aligns with conservation priorities and sustainable resource management.

The session concluded with a shared vision for the future and a clear commitment to strengthening Italy-China collaboration in polar sciences, with three major takeaways:

The establishment of a MoU between PRIC and ISP-CNR to enhance cooperation, improve resource allocation, and maximize the efficiency of research infrastructure.

A shared commitment to the protection of the Ross Sea MPA, with both nations leveraging their research presence to advocate for sustainable policies and responsible scientific exploration.

The need for continued investment in Arctic and Antarctic research, focusing on climate change, marine ecosystem monitoring, and permafrost degradation.

As polar regions face unprecedented environmental challenges, Italy and China have an opportunity to lead the way in international cooperation, ensuring that scientific research contributes to both climate mitigation and ecosystem conservation. The discussions held at this session serve as a foundation for future collaborations, reinforcing the vital role of Italy-China scientific diplomacy in polar research.



# PETROGENESIS OF THE HUGHES BLUFF GRANITIC PLUTON IN THE TRANSANTARCTIC MOUNTAINS, ANTARCTICA AND THE POTENTIAL FIELDS OF BILATERAL COOPERATION BETWEEN CHINA AND ITALY

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**Keywords:** i-type granites, geochemistry of granitic plutons, fractional crystallization, subduction-related magmatism, rare earth element patterns

## 1. Introduction

The Transantarctic Mountains are one of the continental-scale mountain systems in the world, extending over 3,000 km from the Oates Coast along the Pacific margin of Antarctica to the Ronne Ice Shelf in the Weddell Sea. The Precambrian basement of this region records the transition from a passive continental margin to an active margin during the Late Neoproterozoic to Early Paleozoic<sup>1</sup>. Consequently, the basement rocks underwent widespread metamorphism, deformation, uplift, and erosion, accompanied by extensive magmatic intrusion. These geological processes are collectively referred to as the Ross Orogeny<sup>2</sup>, which reflects the convergence between the paleo-Pacific plate and the East Antarctic plate during the Late Neoproterozoic to Early Paleozoic.

Magmatism associated with the Transantarctic Mountains orogen is well developed, predominantly occurring as plutons, accompanied by minor volcanic units<sup>3</sup>, which are known as the Granite Harbor Intrusives<sup>4</sup>, consisting primarily of felsic rocks with subordinate ultramafic to mafic components. The magmatic assemblage is dominated by

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<sup>1</sup> STUMP 1995; FAURE, MENSING 2011; GOODGE 2020, 347-359.

<sup>2</sup> STUMP 1995.

<sup>3</sup> ENCARNACIÓN *et al.* 1999, 497-504; WAREHAM *et al.* 2001, 360-372.

<sup>4</sup> GUNN, WARREN 1962, 1-157.

calc-alkaline rocks, with minor alkaline varieties, and its volume diminishes progressively from the Ross Sea toward the Pensacola Mountains<sup>5</sup>.

Borg *et al.* (1987) and Vetter and Tessensohn (1987) found that the inland (Polar Plateau–proximal) parts of the terrane are dominated by peraluminous two-mica granites exhibiting S-type characteristics, whereas the outer, more distal zones are composed mainly of granodiorites to quartz diorites displaying I-type granite features within the Wilson Terrane of northern Victoria Land. These petrological differences reflect an active continental margin tectonic setting. Furthermore, the variation in major and trace element compositions from the interior to the exterior suggests progressively greater crustal involvement in the magmatic sources, which testified by the Oxygen isotope data<sup>6</sup>. Additionally, Read *et al.* (2002) and Cottle and Cooper (2006) identified A-type granitoid melts associated with regional extensional regimes. Goodge *et al.* (2012), focusing on the central Transantarctic Mountains, also revealed that magmatic activity in this region spanned a prolonged period of up to 100 million years and exhibited a seaward migration of magmatic centers, which may reflect slab rollback and forearc thickening during orogenic contraction.

To date, the works of Stump (1995), Goodge (2020), and Faure and Mensing (2011) have provided systematic syntheses on the Granite Harbor Intrusives. Available data suggest that the Granite Harbor Intrusives can be subdivided into pre-tectonic, syn-tectonic, and post-tectonic magmatic phases<sup>7</sup>. However, due to extensive erosion of the orogenic belt, the presence of thick overlying Gondwana sequences and younger glacial deposits, and the fact that the interior of the Transantarctic Mountains is covered by the modern ice sheet, our understanding of Ross Orogeny magmatism remains limited.

The Hughes Bluff granitoid, located south of David Glacier, is part of the Granite Harbor Intrusives and has thus far remained unstudied. In this work, we conduct a petrogenetic investigation of the Hughes Bluff granitoid. Petrographic and geochemical analyses indicate that this body is an I-type granite, likely derived from lower crustal sources but with evidence of mantle-derived material involvement. During magmatic evolution, it underwent varying degrees of fractional crystallization involving plagioclase, ilmenite, rutile, and apatite. Integrating the geochemical characteristics with regional geological context, we infer that the Hughes Bluff intrusion formed in a subduction-related volcanic arc setting.

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<sup>5</sup> STUMP 1995.

<sup>6</sup> DALLAI *et al.* 2002, 223-241; DALLAI *et al.* 2003, 135-151.

<sup>7</sup> ALLIBONE *et al.* 1993, 281-297; GOODGE *et al.* 1993, 37-40; ENCARNACIÓN, GRUNOW 1996, 1325-1341; GOODGE *et al.* 2012, 2027-2065.

## 2. Geological background

Scholars have previously conducted systematic syntheses of the geological characteristics of the Transantarctic Mountains<sup>8</sup>, noting that the major uplift of this mountain primarily occurred during the Late Mesozoic and Early Cenozoic<sup>9</sup>. The oldest exposed rocks in the mountains are the Mesoarchean Nimrod Complex, located in the central Miller Range–Geologists Range area<sup>10</sup>. This complex not only records the Paleoproterozoic Nimrod Orogeny but also preserves evidence of the Early Paleozoic Ross Orogeny.

The formation of the Early Paleozoic Ross Orogenic Belt resulted from the westward subduction of the paleo-Pacific plate beneath the East Antarctic craton<sup>11</sup>. Among the best-exposed and most intensively studied sections of the Ross Orogenic Belt is Northern Victoria Land, located between the Oates Coast along the Pacific margin and the Ross Sea. This region exhibits complex regional geological structures, which, from the continent toward the ocean, are divided into the Wilson Terrane, Bowers Terrane, and Robertson Bay Terrane<sup>12</sup> (Fig. 1a). The Wilson Terrane is composed mainly of multiply deformed low- to high-grade metasedimentary rocks and migmatites, which record deposition in both passive and active margin environments. The transition between these two settings, marking the initiation of subduction, occurred around ~550 Ma<sup>13</sup>. The Ross Orogeny led to localized ultrahigh-pressure eclogite-facies metamorphism in rocks of the Wilson Terrane (1.6-3.3 GPa,  $T \approx 750\text{-}850^\circ\text{C}$ )<sup>14</sup>, as well as widespread intrusion by magmatic bodies related to different evolutionary stages of the Ross orogenesis<sup>15</sup>. The magma sources were mainly deep crustal melts or mantle-derived, showing substantial compositional variation, and the mafic and felsic magmas were not derived from the same magmatic source<sup>16</sup>. The final stages of mafic and felsic magmatism are thought to be related to slab rollback<sup>17</sup>.

The Bowers Terrane consists primarily of low-grade metamorphosed Middle Cambrian to Early Ordovician volcanic-sedimentary rocks<sup>18</sup>, with the volcanic units exhibiting oceanic

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<sup>8</sup> STUMP 1995, 1-284; FAURE, MENSING 2011, 1-804; GOODGE 2020, 347-359.

<sup>9</sup> GOODGE 2020, 347-359.

<sup>10</sup> GOODGE, FANNING 2016, 242-271.

<sup>11</sup> ESTRADA *et al.* 2016, 426-448.

<sup>12</sup> WEAVER *et al.* 1984, 128-794.

<sup>13</sup> ESTRADA *et al.* 2016, 426-448.

<sup>14</sup> DI VINCENZO *et al.* 1997, 1391-1417.

<sup>15</sup> ARMIENTI *et al.* 1990, 103-124.

<sup>16</sup> COOPER *et al.* 2007.

<sup>17</sup> ROCCHI *et al.* 2009, 801-819.

<sup>18</sup> WEAVER *et al.* 1984, 128-794

island arc geochemical signatures<sup>19</sup>. The Robertson Bay Terrane, by contrast, is composed mainly of Late Cambrian to Early Ordovician deep-water turbidites<sup>20</sup>, similar with the subduction accretionary wedge setting<sup>21</sup>. The Bowers Terrane is fault-bounded, with the Lantermann Fault separating it from the Wilson Terrane, and the Leap Year Fault separating it from the Robertson Bay Terrane<sup>22</sup>. After the accretion of these three terranes, the region was intruded by Devonian to Early Carboniferous Admiralty Intrusives and accompanied by the eruption of the Gallipoli Volcanics<sup>23</sup>.

The Ross Orogeny induced regional uplift and erosion, a process that continued into the Late Silurian or Early Devonian, leading to the formation of the regionally extensive Kukri Erosion Surface<sup>24</sup>. Above this erosional surface were deposited the Silurian–Triassic continental sedimentary sequences of the Beacon Supergroup<sup>25</sup>. These, together with the crystalline basement, were intruded by Jurassic Kirkpatrick Basalts and Ferrar Dolerites<sup>26</sup>, followed by deposition of the Late Cenozoic McMurdo Volcanic Group and glacial sediments.

Fault structures are among the most prominent structural features of Northern Victoria Land. The main faults are northwest–southeast-trending dextral strike-slip faults, such as the Lantermann Fault between the Bowers and Wilson Terranes and the Leap Year Fault between the Wilson and Robertson Bay Terranes<sup>27</sup>. These are primarily Early Paleozoic faults<sup>28</sup>, which have experienced varying degrees of later reactivation<sup>29</sup>. In addition, the region is cut by northeast–southwest-trending faults associated with dextral trans tensional regimes<sup>30</sup>.

Hughes Bluff is located south of David Glacier and forms a nunatak rising above the ice sheet. Tectonically, it belongs to the Wilson Terrane, where numerous outcrops of Ross Orogeny–related intrusive rocks are exposed. To its north lies the David magnetic lineation, while the B1 magnetic lineation lies to its southwest. Ferraccioli and Bozzo (2003) have suggested that these magnetic lineations may represent Neogene normal faults (Fig. 1).

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<sup>19</sup> ROCCHI *et al.* 2011, 594-607.

<sup>20</sup> GOODGE 2007, 185-203.

<sup>21</sup> ESTRADA *et al.* 2016, 426-448.

<sup>22</sup> CAPPONI *et al.* 1999, 249-266.

<sup>23</sup> FEDERICO *et al.* 2010, 667-684.

<sup>24</sup> ISBELL 1999, 228-238.

<sup>25</sup> BARRETT 1981, 447-458.

<sup>26</sup> ANTONINI *et al.* 1999, 1-19.

<sup>27</sup> CAPPONI *et al.* 1999, 249-266.

<sup>28</sup> FERRACCIOLI *et al.* 2009, 43-61.

<sup>29</sup> ROSSETTI *et al.* 2000, 60-66; DI VINCENZO *et al.* 2004, 349-364.

<sup>30</sup> SALVINI *et al.* 1997, 24669-24696.

### 3. Field geology

The Hughes Bluff pluton covers an area of approximately 1.7 km<sup>2</sup>. Due to safety considerations and time constraints, a comprehensive survey of all exposed outcrops was not conducted; instead, geological observations and sampling were carried out only in the vicinity of the helicopter landing site. Overall, the pluton has been strongly affected by glacial processes, as evidenced by the presence of Roche Mountains, glacial striations, and polished surfaces, indicating that the advance and retreat of the David Glacier have exerted a significant influence on the landforms and geomorphology of the pluton. The granite body is generally reddish-brown in color, with potassium feldspar occurring as phenocrysts that show a preferred orientation, with an overall east-west (280°) strike. Additionally, domino structures are present, indicating the direction of deformation and movement. Gray enclaves are also observed within the pluton; however, due to the extreme difficulty in identifying optimal sampling sites, no samples of these enclaves were collected. The main plutonic body has been crosscut by later intrusions of medium- to fine-grained granite dikes, approximately 30 cm wide, in which micas exhibit clear foliation aligned with the orientation of the potassium feldspar. Furthermore, the pluton is cut by X-type joints, which have caused significant localized fracturing of the rocks, with joint surfaces that are notably smooth.

### 4. Samples and methods

Samples 35LC108-2 and 35LC108-3 were collected at 75.3990°S, 162.2040°E, while sample 35LC108-4 was collected at 75.3976°S, 162.1975°E. Among these, 35LC108-2 and 35LC108-4 were taken from the main body of the pluton, while 35LC108-3 represents a later intrusive dike (Fig.1).

In the laboratory, the specimens were first subjected to visual examination and documentation, followed by thin-section preparation and petrographic analysis to determine which samples would be selected for whole-rock geochemical analysis. The selected samples were then pulverized to a grain size of 0.075 mm for major and trace (including rare earth) element analyses.

Major element analyses were conducted at Qingdao Superlab Testing Co., following the procedure outlined below: rock powder samples were first dried at 105°C, then precisely weighed (0.5000 g) and mixed with 4.000 g of flux (Li<sub>2</sub>B<sub>4</sub>O<sub>7</sub>) in a 30 mL porcelain crucible. The mixture was transferred to a platinum-gold crucible, with three drops of 10% LiBr solution added. The crucible was then placed in a fusion machine, gradually heated to 1050°C, and held for 60 seconds to ensure full oxidation. The temperature was maintained at 1050°C for sample fusion, during which the crucible was continuously

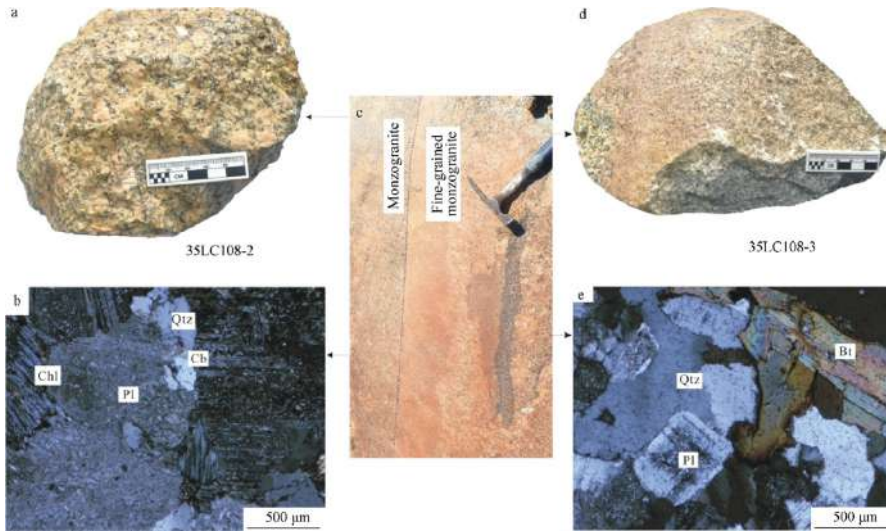


Fig. 1. Outcrop and photomicrographs of the Hughes Bluff pluton.

(a) Photograph of the sample 35LC108-2; (b) Photomicrograph of the monzogranite sample 35LC108-2 (crossed-polarized light); (c) Photograph of the outcrop of monzogranite and dyke; (d) Photograph of the sample 35LC108-3; (e) Photomicrograph of the finegrained monzogranite sample 35LC108-3 (crossed-polarized light) Qtz-quartz; Pl-plagioclase; Bt-biotite; Chl-chlorite; Cb-carbonate.

agitated in all directions for 15 minutes. After fusion, the crucible was left to stand for 60 seconds, then removed and allowed to cool by repeated inversion. The resulting glass disk was extracted intact, with a smooth, bubble-free, and inclusion-free surface, labeled with the sample number, and prepared for instrumental analysis. Major elements ( $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{TFe}_2\text{O}_3$ ,  $\text{MgO}$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{P}_2\text{O}_5$ ,  $\text{TiO}_2$ ,  $\text{MnO}$ , etc.) were analyzed using a Rigaku ZSX Primus II X-ray fluorescence (XRF) spectrometer. Analytical quality was monitored using standard reference materials AGV-2, GSR-4, GSD-2, and GSR-3, with all measured values falling within the certified ranges and associated uncertainties. Analytical precision was maintained within 2% deviation. For every five samples analyzed, a parallel sample was prepared to ensure consistency and control experimental stability.

Trace element analyses were carried out at the First Institute of Oceanography, Ministry of Natural Resources. Specifically, 50.00 mg of sample powder was accurately weighed into Teflon digestion vessels, wetted with a few drops of ultrapure water, followed by the addition of 1.50 mL ultrapure  $\text{HNO}_3$  and 1.50 mL ultrapure  $\text{HF}$ , and thoroughly mixed. The vessels were sealed in stainless steel jackets and placed in an oven at  $190^\circ\text{C}$  for more than 48 hours for digestion. After cooling, the digestion vessels were placed on a hot plate to evaporate to dryness, followed by the addition of 1 mL  $\text{HNO}_3$  and evaporation to

a moist salt state. Subsequently, 3 mL of 50% HNO<sub>3</sub> and 0.5 mL of Rh internal standard solution ( $1.0 \times 10^{-6}$ ) were added, resealed in the stainless-steel jackets, and heated in a 150°C oven for over 8 hours to ensure complete extraction. After cooling, the solutions were diluted with deionized water to a final mass of 50.00 g. A 10.00 g aliquot was taken and further diluted to 20.00 g with deionized water for analysis. Elemental concentrations, including Li, Be, Co, Cr, Ni, Cu, Ga, Ge, Rb, Nb, Mo, Cd, In, Cs, Hf, Ta, W, Tl, Pb, Bi, Th, U, Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu, were measured using a Thermo X Series 2 ICP-MS analytical system.

## 5. Results

### 5.1 Petrography

#### 5.1.1 Sample 35LC108-2

The lithology is monzogranite, with a reddish-brown color, medium- to coarse-grained granitic texture, and massive structure (Fig. 1a). The main minerals are plagioclase, K-feldspar, quartz, and biotite (Fig. 1b). Plagioclase (38-40%) is subhedral prismatic, mostly 2-4 mm in size, with some grains 0.5-2.0 mm. It shows pronounced alteration to clay minerals and sericite, making the surfaces appear cloudy. K-feldspar (23-45%) is anhedral granular, mostly 2-5 mm, with some grains 1-2 mm, showing slight alteration to clay minerals. K-feldspar often contains or is intergrown with plagioclase and biotite, forming inclusion and intergrowth textures. Quartz (20-23%) is anhedral granular, mostly 2-4 mm, clean and colorless. Biotite (5-8%) is subhedral tabular, 0.10-1.75 mm, mostly strongly chloritized, with black opaque minerals precipitated along cleavage planes. Accessory minerals mainly include zircon and allanite. Secondary minerals include kaolinite, carbonate minerals, and sericite.

#### 5.1.2 Sample 35LC108-3

The lithology is monzogranite, gray-brown in color, fine-grained granitic texture, with a massive structure (Fig. 1d). The main minerals are plagioclase, K-feldspar, quartz, and biotite (Fig. 1e). Plagioclase (48-50%) is subhedral tabular-prismatic, mostly 0.2-2.0 mm, with some grains 2.0-4.5 mm, mostly altered to sericite and clay minerals. Some grains display zoning, with strongly altered cores and cleaner rims forming a sieve texture. K-feldspar (18-20%) is anhedral granular, mostly 0.2-2.0 mm, with some grains 2-4 mm, showing slight clay alteration. Quartz (23-25%) is anhedral granular, mostly 0.2-2.0 mm, with some grains 2.0-4.5 mm, clean and colorless. Biotite (5-8%) is subhedral tabular, 0.2-1.5 mm, some slightly chloritized. Accessory minerals mainly include titanite.

### 5.1.3 Sample 35LC108-4

The lithology is monzogranite, pinkish in color, with a porphyritic texture and massive structure. The rock consists mainly of phenocrysts and groundmass. Phenocrysts are mostly microcline (13-15%), subhedral tabular-prismatic, 10-20 mm in size, with significant clay alteration on the surfaces. The groundmass consists mainly of plagioclase, K-feldspar, quartz, and biotite. Plagioclase (28-30%) is subhedral prismatic, mostly 2-4 mm, with some grains 0.5-2.0 mm, showing strong clay and sericite alteration. Some plagioclase rims intergrow with quartz, forming micro-worm textures. K-feldspar (23-25%) is anhedral granular, 1-5 mm, showing clay alteration and slight carbonatization, often intergrown with plagioclase and biotite, forming intergrowth textures. Quartz (20-23%) is anhedral granular, mostly 1.0-4.5 mm, clean and colorless. Biotite (3-5%) is subhedral tabular, 0.10-1.25 mm, partially chloritized, with black opaque minerals precipitated along cleavage planes. Accessory minerals mainly include titanite, apatite, epidote, and allanite.

## 5.2 Geochemical Characteristics of the Rocks

### 5.2.1 Major Element Characteristics

The main-phase monzogranites (samples 35LC108-2 and 35LC108-4) have SiO<sub>2</sub> contents ranging from 70.50% to 71.20%, with an average of 70.85%. Na<sub>2</sub>O ranges from 3.86% to 4.07% (average 3.97%), and K<sub>2</sub>O ranges from 4.17% to 4.44% (average 4.43%). The total alkali content (Na<sub>2</sub>O+K<sub>2</sub>O) ranges from 8.37% to 8.65%, with K<sub>2</sub>O/Na<sub>2</sub>O ratios of 1.09-1.15, indicating relative potassic enrichment. The average Al<sub>2</sub>O<sub>3</sub> content is 14.00%, and the average CaO content is 1.75%. The aluminum saturation index ( $A/CNK = Al_2O_3 / (K_2O + Na_2O + CaO)$ , molar ratio) ranges from 0.95 to 0.98, and the A/NK ( $Al_2O_3 / (K_2O + Na_2O)$ , molar ratio) is 1.22-1.26, classifying these rocks as metaluminous. The rocks have a Shand index ( $\sigma$ ) of 2.15-2.55 and Mg<sup>#</sup> values between 38.92 and 41.55. In the CIPW normative mineral calculation, corundum appears at 0.36-0.64%, with no diopside present. These rocks belong to the metaluminous calc-alkaline granite series.

The fine-grained monzogranitic dike (sample 35LC108-3) has major element results also shown in Table 1. Its SiO<sub>2</sub> content is 74.47%, CaO 1.63%, Na<sub>2</sub>O 4.06%, and K<sub>2</sub>O 4.17%, giving a total alkali content (Na<sub>2</sub>O+K<sub>2</sub>O) of 8.25% and K<sub>2</sub>O/Na<sub>2</sub>O ratio of 1.03, indicating relative potassic enrichment. The Al<sub>2</sub>O<sub>3</sub> content is 13.36%, with an aluminum saturation index (A/CNK) of 0.94 and A/NK of 1.19, classifying it as metaluminous. The Shand index ( $\sigma$ ) is 2.15, and the Mg<sup>#</sup> is 22.28. The CIPW normative mineral calculation shows 0.61% diopside and no corundum, also placing it in the metaluminous calc-alkaline series.

### 5.2.2 Trace Element Characteristics

The monzogranites (samples 35LC108-2 and 35LC108-4) are notably enriched in Ba, Sr, Zr, and Rb, with contents ranging between  $1124.32 \times 10^{-6}$ – $123.89 \times 10^{-6}$ ,  $369.72 \times 10^{-6}$ – $625.32 \times 10^{-6}$ ,  $112.33 \times 10^{-6}$ – $179.32 \times 10^{-6}$ , and  $133.03 \times 10^{-6}$ – $149.48 \times 10^{-6}$ , respectively. The Nb/Ta ratio ranges from 8.69 to 12.57, generally lower than the mantle-derived magma Nb/Ta ratio of  $\sim 17$  (Hofmann, 1988; Green, 1995). In the primitive mantle-normalized trace element spider diagram (Fig. 2a), the monzogranites show distinct positive anomalies for K, La, Pb, P, and Zr, and negative anomalies for U, Ta, Nb, Ce, Sm, and Ti, displaying a right-leaning pattern.

The fine-grained monzogranitic dike (sample 35LC108-3) also shows high Ba, Sr, Zr, and Rb contents, at  $1124.32 \times 10^{-6}$ ,  $369.72 \times 10^{-6}$ ,  $112.33 \times 10^{-6}$ , and  $138.87 \times 10^{-6}$ , respectively. In the primitive mantle-normalized spider diagram (Fig. 2a), this dike similarly shows distinct positive anomalies for K, La, Pb, and Zr, and negative anomalies for U, Ta, Nb, P, Sm, and Ti, also displaying a right-leaning pattern.

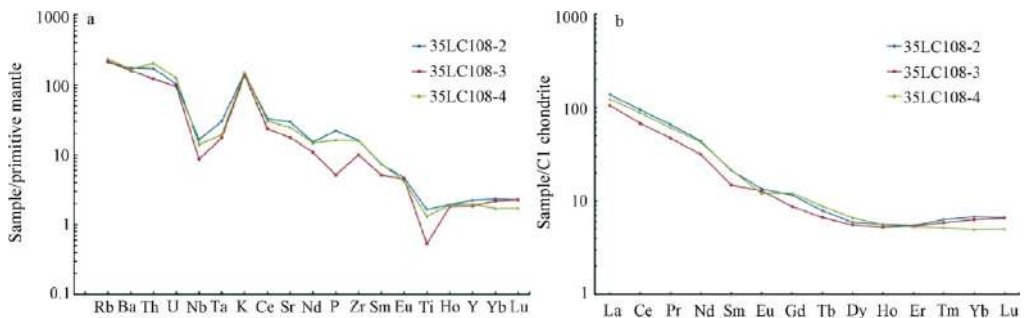


Fig. 2. Primitive mantle (PM) normalized spider diagram (a) and chondrite-normalized REE pattern (b) for the Hughes Bluff pluton (Chondrite and PM values used for normalization are from Sun and McDonough, 1989).

### 5.2.3 Rare Earth Element (REE) Characteristics

The monzogranites (samples 35LC108-2 and 35LC108-4) have relatively low total REE contents ( $\Sigma$ REE), ranging from  $120.06 \times 10^{-6}$  to  $128.76 \times 10^{-6}$ . Light rare earth elements (LREE) are relatively enriched, while heavy rare earth elements (HREE) are depleted, with LREE/HREE ratios of 16.66–17.69. The chondrite-normalized REE distribution curves display a right-leaning pattern, indicating significant LREE–HREE fractionation ((La/Yb)N = 15.71–23.70), and show a slight negative Eu anomaly ( $\delta$ Eu = 0.72–0.83; Fig. 2b).

The fine-grained monzogranitic dike (sample 35LC108-3) also shows low total REE content at  $95.05 \times 10^{-6}$ , with relative LREE enrichment and HREE depletion (LREE/HREE = 14.75). The chondrite-normalized REE distribution curve also shows a right-leaning pattern, clear LREE-HREE fractionation ((La/Yb)<sub>N</sub> = 23.70), and a slight positive Eu anomaly ( $\delta\text{Eu} = 1.10$ ; Fig. 2b).

## 6. Discussion

### 6.1 Rock Genesis

Granites are the most widely distributed rock types on Earth and constitute an important component of the continental crust. Although the mineral composition of granites is not particularly complex compared to those of the other rock types, they show great diversity in types<sup>31</sup>. Currently, the most widely accepted granite genesis classification scheme is the MISA classification, in which M-type granites are relatively rare. However, this classification is not always applicable to granites that have undergone high degrees of fractional crystallization, where both mineral composition and chemical characteristics approach eutectic compositions<sup>32</sup>. Therefore, before discussing the genesis and classification of a granite body, it is necessary to first assess whether it has experienced strong fractional crystallization.

Highly fractionated granites have distinct geological, petrographic, mineralogical, and geochemical signatures, which have been systematically summarized by Wu et al. (2017). In the Hughes Bluff pluton, there are no characteristic minerals of highly fractionated granites, such as Li-tourmaline, lepidolite, or Li-muscovite. The elemental composition lacks peraluminous characteristics, and the REE patterns do not show the four-component effect characteristic of highly fractionated granites<sup>33</sup>. Furthermore, on the binary diagram (K<sub>2</sub>O+Na<sub>2</sub>O)/CaO vs. (Zr+Nb+Ce+Y) (Fig. 3a), all analyzed samples plot within the unfractionated granite field, indicating that the Hughes Bluff pluton does not belong to the highly fractionated granite category.

Neither the monzogranites nor the fine-grained monzogranitic dikes of the Hughes Bluff pluton show the presence of typical minerals (such as hornblende, cordierite, or alkali minerals) that would indicate I-, S-, or A-type granite<sup>34</sup>. Therefore, it is difficult to determine their genesis type solely based on mineralogy. Among the commonly used geochemical

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<sup>31</sup> Wu et al. 2007, 1217-1238.

<sup>32</sup> Wu et al. 2007, 1217-1238.

<sup>33</sup> Wu et al. 2017, 1201-1219.

<sup>34</sup> Wu et al. 2007, 1217-1238.

indicators for granite classification, values of  $10,000 \times (Ga/Al) > 2.6$ ,  $Zr > 250 \times 10^{-6}$ , and  $Zr+Nb+Ce+Y > 350 \times 10^{-6}$  are often considered effective criteria for identifying A-type granites (Wu *et al.*, 2007). The Hughes Bluff pluton, however, shows  $10,000 \times (Ga/Al) < 2.6$ ,  $Zr < 250 \times 10^{-6}$ , and  $Zr+Nb+Ce+Y < 350 \times 10^{-6}$ , which do not match the typical geochemical characteristics of A-type granites. In addition, the REE partitioning patterns of the Hughes Bluff pluton do not display the characteristic “seagull-shaped” REE pattern typical of A-type granites<sup>35</sup>. Therefore, the Hughes Bluff pluton does not belong to the A-type granite category.

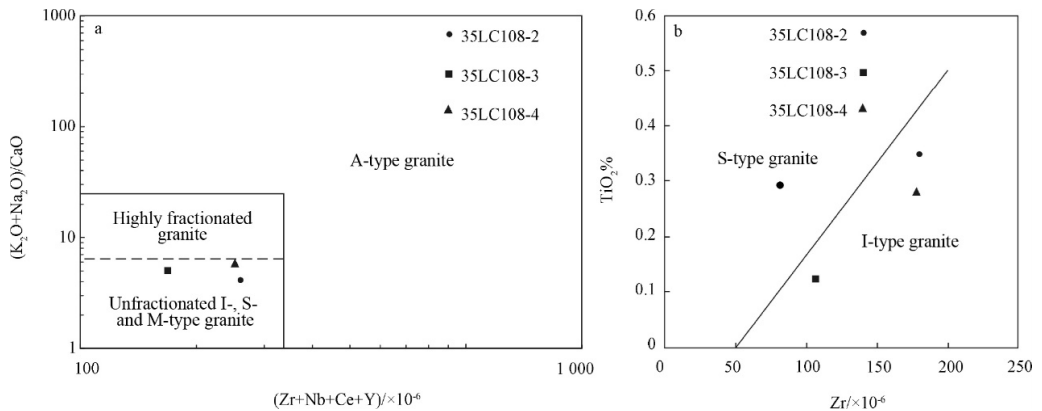


Fig. 3. Petrogenesis discrimination diagrams for the Hughes Bluff granitic pluton.  
 (a)  $(K_2O+Na_2O)/CaO$ – $(Zr+Nb+Ce+Y)$  diagram (modified after Whalen *et al.* 1987);  
 (b)  $TiO_2$ – $Zr$  diagram (modified after Liu *et al.* 2016, 848-860).

From the perspective of CIPW normative minerals, the monzogranites of the Hughes Bluff pluton contain a small amount (<1%) of normative corundum but no diopside, while the fine-grained monzogranitic dikes contain a small amount (<1%) of normative diopside but no corundum. Both rock types have aluminum saturation indices below 1, indicating they belong to the metaluminous series. Compared with the typical characteristics of I-type and S-type granites<sup>36</sup>, the analyzed samples are more consistent with I-type granites. Furthermore, in the  $TiO_2$ – $Zr$  discrimination diagram (Fig. 3b), all samples plot within the I-type granite field. Taken together, these data indicate that the Hughes Bluff pluton should be classified as an I-type granite.

<sup>35</sup> WANG *et al.* 2018, 382-396.

<sup>36</sup> CHAPPELL, WHITE 2001, 489-499.

## 6.2 Magma Source Region and Evolutionary Processes

Magma generally refers to a high-temperature, viscous silicate melt, often mixed with solids and riched in volatiles, formed by partial melting of the upper mantle or crust. The Hughes Bluff pluton has SiO<sub>2</sub> contents ranging from 70.50% to 74.47%, Al<sub>2</sub>O<sub>3</sub> contents exceeding 13%, K<sub>2</sub>O contents above 4%, and Na<sub>2</sub>O contents above 3% but lower than K<sub>2</sub>O. Typically, in rocks with SiO<sub>2</sub> >71%, the Al<sub>2</sub>O<sub>3</sub> content is no more than 12%<sup>37</sup>, suggesting that the pluton mainly originated from crustal material melting and emplacement. The depletion of Nb and Ta also points to a close relationship with continental crust, as Nb and Ta preferentially remain in the mantle during the early stages of continental crust formation from primitive mantle<sup>38</sup>. The Nb/Ta ratio of the Hughes Bluff pluton ranges from 8.69 to 12.97, lower than the average mantle-derived rock value (17.5±2.0)<sup>39</sup> and closer to the average value of continental crust rocks (11)<sup>40</sup>. Additionally, the REE distribution curves show a rightward (LREE-enriched) pattern, further indicating a crustal source environment.

The Rb/Sr ratio is also often used to assess the source characteristics of granitic rocks. The Hughes Bluff pluton has Rb/Sr ratios between 0.21 and 0.38, much higher than the upper mantle's Rb/Sr ratio (0.034)<sup>41</sup>, providing further evidence of a crustal source.

The pluton shows relatively low Sr, Yb, and Y contents, suggesting a source region under medium to high pressure conditions (0.8-1.5 GPa)<sup>42</sup>. The Al<sub>2</sub>O<sub>3</sub>/TiO<sub>2</sub> ratio is an important indicator of magma formation temperature: if the value exceeds 100, the source region's temperature is below 875°C; if lower, it indicates temperatures above 875°C<sup>43</sup>. The Al<sub>2</sub>O<sub>3</sub>/TiO<sub>2</sub> ratio of the Hughes Bluff pluton is below 100, implying source temperatures above 875°C, consistent with the thermal regime of the Ross Orogenic tectonic setting<sup>44</sup>. The Mg<sup>#</sup> values (<40) are also low, indicating that the magma was generated by partial melting of mafic lower crust<sup>45</sup>. Moreover, the Zr/Hf ratio of the pluton ranges from 35.58 to 37.73, which is higher than the typical crustal source value (33)<sup>46</sup> and closer to mantle-derived rock values (36 ± 2.0)<sup>47</sup>, suggesting possible mantle material involvement.

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<sup>37</sup> LI *et al.* 2007, 565-582.

<sup>38</sup> GREEN 1995, 347-359.

<sup>39</sup> HOFMANN 1988, 297-314; GREEN 1995, 347-359.

<sup>40</sup> TAYLOR, McLENNAN 1985, 1-312; GREEN 1995, 347-359.

<sup>41</sup> GUO *et al.* 2019, 286-300.

<sup>42</sup> MENG *et al.* 2018, 513-546.

<sup>43</sup> HE *et al.* 2020, 1822-1830.

<sup>44</sup> DI VINCENZO *et al.* 1997, 1391-1417.

<sup>45</sup> RAPP, WATSON 1995, 891-931.

<sup>46</sup> TAYLOR, McLENNAN 1985, 1-312; GREEN 1995, 347-359.

<sup>47</sup> TAYLOR, McLENNAN 1985, 1-312; GREEN 1995, 347-359.

Magma in the source region often undergoes complex evolutionary processes. Both the monzogranites and fine-grained monzogranitic dikes display clearly Ti depletion, indicating the separation and crystallization of Ti-rich minerals such as ilmenite and rutile in the source. Phosphorus is enriched in the monzogranites but depleted in the fine-grained monzogranitic dikes, suggesting that the main-phase magma did not experience the same degree of apatite separation and crystallization as the late-stage magma. The main monzogranites show weak negative Eu anomalies, which may indicate that the magma originated from low-degree partial melting and underwent some degree of plagioclase fractional crystallization. In contrast, the fine-grained monzogranitic dikes exhibit weak positive Eu anomalies, indicating less pronounced magma differentiation, possibly related to the characteristics of the protolith and the crystallization temperature-pressure conditions.

### 6.3 Tectonic Setting

The tectonic setting of granitoid rock formation is an important aspect of granite research. However, the inherited nature of the source region and melting differentiation processes can both affect the final composition of granitoids, complicating the determination of their tectonic setting. Therefore, multiple methods are typically used together<sup>48</sup>.

The main monzogranites of the Hughes Bluff pluton are enriched in Rb and K and show weak negative Eu anomalies. Such features in granites are often considered to reflect the characteristics of the parental magma<sup>49</sup>. Thus, the geochemical features of the Hughes Bluff pluton can be used to infer its formation environment. Both the monzogranites and fine-grained monzogranitic dikes display marked depletion of high-field-strength elements such as Nb, Ta, and Ti, which is typically regarded as a feature of arc magmatic rocks related to subduction processes<sup>50</sup>. Additionally, in the Y-Nb and (Y+Nb)-Rb tectonic discrimination diagrams (Fig. 4), both the monzogranites and fine-grained dikes plot within the volcanic island arc field.

Moreover, the Hughes Bluff pluton exhibits potash feldspar lineation, a structural feature common in the region, which is generally considered to be related to subduction processes associated with the Ross Orogeny<sup>51</sup>. Furthermore, the nearby granitoid body at Irizar Cape has zircon U-Pb ages of  $489.9 \pm 4.4$  Ma<sup>52</sup> and similar elemental compositions to the Hughes Bluff pluton and is considered to have formed in an extensional environment

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<sup>48</sup> WU *et al.* 2007, 1217-1238.

<sup>49</sup> MA *et al.* 1998, 431-456.

<sup>50</sup> ZHANG *et al.* 2015, 339-354.

<sup>51</sup> CAPPONI *et al.* 2020, 702-709.

<sup>52</sup> ROCCHI *et al.* 2009, 801-819.

during the latest stage of the Ross Orogenic Belt. Taken together, these data suggest that the Hughes Bluff pluton was generated in an active continental margin magmatic arc setting.

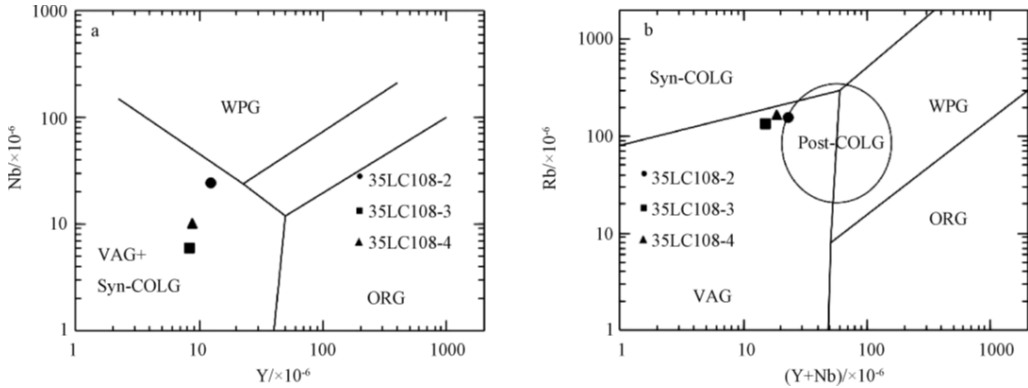


Fig. 4. Diagrams showing the tectonic setting of Y-Nb (a) and (Y+Nb)-Rb (b) for the Hughes bluff pluton (a after Pearce *et al.*, 1984; b after Pearce, 1996). ORG-oceanic ridge granites; WPG-within-plate granites; VAG-volcanic arc granites; Syn-CLOG-syncollisional granites; Post-CLOG-postcollisional granites.

## 7. Conclusion

The main rock type of the Hughes Bluff pluton is monzogranite, which was later intruded by fine-grained monzogranitic dikes. Both the monzogranites and the fine-grained monzogranitic dikes are characterized by high silica, high potassium, and alkali enrichment, belonging to metaluminous calc-alkaline granitoids. The rocks are generally enriched in large ion lithophile elements such as Rb, Th, K, and U, while significantly depleted in Nb and Ti, showing geochemical characteristics typical of island arc granites. The genetic type is classified as I-type granite.

The source region of the Hughes Bluff pluton was likely the lower crust, but with some mantle-derived material involvement. Within the source region, the magma experienced varying degrees of fractional crystallization involving plagioclase, ilmenite, rutile, and apatite. The Hughes Bluff pluton formed in a volcanic island arc setting related to subduction processes. Further geochronological data will help to better constrain its formation environment.

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## THE NATIONAL RESEARCH PROGRAM IN ANTARCTICA, 40 YEARS OF ITALIAN RESEARCH IN ANTARCTICA

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**Keywords:** polar sciences, paleoclimate reconstruction, Antarctic biology and astrobiology, environmental protection and marine conservation, climate change and earth/ice interactions

The National Research Program in Antarctica was born with the law of 1985. In the expedition 1985-86 the first camp was built in Terranova Bay in Victoria Land on the Ross Sea. In the following years the Station that is now called Mario Zucchelli was built and completed with the new operations room. In 1998 the construction of the Italian-French Station Concordia began, on the Polar Plateau at 3200 m altitude. Some flagship experiments that were carried out during the PNRA (National Research Program in Antarctica) are the Boomerang experiment that described the primordial Universe, the Ape-Gaia experiment that carried out studies on the ozone hole, the EPICA experiment that reconstructed the paleoclimate up to over 800,000 years ago and the Cape Roberts experiment to reconstruct the glaciation streak from 17 to 34 million years ago. Important is also the contribution to Antarctic biology, for example the comparison between the Dry Valleys of Antarctica and the surface of Mars led to experiments being carried out on the International Space Station that have demonstrated the possibility of the survival of Antarctic microorganisms on Mars.

Currently, Italy has the Mario Zucchelli Station, and the Concordia Station on the Antarctic Plateau, with the Summer Camp attached, which is occupied by research personnel during the Antarctic summer; then we also have the icebreaker *Laura Bassi* available.

Currently, the Italian Antarctic stations can be reached by air or by ships that connect both the Mario Zucchelli and Concordia Stations, and the French Dumont D'Urville Station, with Tasmania and New Zealand; the Boulder Clay airstrip was recently completed and came into operation. Furthermore, the National Antarctic Museum is active with its three locations in Genoa, Siena and Trieste.

The National Antarctic Research Program 2024-2026 has 5 scientific priorities: a) Earth/ice/climate interactions, astronomy, b) astrophysics and space weather, c) life in Antarctica, d) human impact and environmental contamination, e) biomedicine and Psychology. Important are also the collection and dissemination of data and training and information.

The vision includes:

- Studying antarctica and the Southern Ocean to study the present and predict the future.
- Finding adequate responses to climate change.
- Training new generations of researchers.

The mission includes:

- Consolidate the Italian presence in Antarctica.
- Strengthen scientific leadership.
- During the fortieth PNRA expedition in Antarctica, 21 scientific projects are implemented, and 18 observatories are active.

Very important are the activities within the Committee for Environmental Protection, in which Italy was the proponent of the Ross Sea Marine Protected Area, one and a half million km<sup>2</sup> of protected area and then Italy is participating with China and Korea in the establishment of a monitoring area within the ASPA of Inexpressible Island for the populations of penguins. We hope that our Chinese colleagues will support us in the monitoring and study activities of the Ross Marine Protected Area.

An important ongoing project is the Beyond Epica-Oldest Ice project, which aims to reconstruct the paleoclimate for one and a half million years by means of ice drilling.

We can conclude by saying that Italy has published 4136 publications to date in international scientific journals with Impact Factor, has created infrastructures for research of the highest level, acquiring cutting-edge technical-scientific skills.

In 40 years, Italy has invested around 900 million Euros and has achieved a place of excellence in Antarctic science.

## FOUR-DIMENSIONAL OBSERVATION FOR MARINE AND POLAR ENVIRONMENT AND ECOSYSTEM

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**Keywords:** four-dimensional marine observation, marine remote sensing technology, ecosystem monitoring, marine environmental dynamics, polar expedition

The Second Institute of Oceanography (SIO) is headquartered in Hangzhou, with branches in Lin'an and Zhoushan. Hangzhou is a city renowned for its historical and cultural heritage and is one of China's most developed modern cities. It is the cradle of the ancient "Liangzhu" culture and the terminus of the historic Beijing-Hangzhou Grand Canal. The area around West Lake in Hangzhou boasts numerous famous scenic spots, and this region inspires our scientific explorations. SIO's research fields include marine resources, marine environmental protection, marine ecosystems, and ocean development and management. SIO houses several top-tier laboratories, among which the State Key Laboratory of Satellite Ocean Environment Dynamics (SOED) stands out as a national key laboratory led by three academicians (two from the Chinese Academy of Sciences and one from the Chinese Academy of Engineering). The laboratory is currently under the directorship of the present author and is supported by three national-level innovative teams and funded by the NSFC and MOST.

SOED focuses on marine remote sensing and four-dimensional observations. Since the 1960s, advancements from ship-based observations and satellite remote sensing to Argo and BGC-Argo observations, and recently to AI-plus observations such as the Intelligent Swift Ocean Observing Device (ISOOD), have positioned SOED as a Chinese pioneer and leader in Marine Remote Sensing and four-dimensional observations. These innovative remote sensing technologies and multi-platform observations have enabled us to better monitor and predict ecological and environmental dynamics from coastal areas to the open ocean and polar seas. We have undertaken numerous tasks including:

- monitoring and prediction of sea levels;
- monitoring and early warning of offshore environments and multiple ecological disasters such as HABs, hypoxia and ocean acidification; monitoring of oil spills and red tides in offshore areas;

- bathymetric mapping in coastal shallow waters with complicated topography;
- benthic habitat mapping of coral reefs; warning and assessment of coral bleaching;
- monitoring and prediction of coastal land deformation; mapping of coastlines, tidal flats, and wetlands (including mangroves);
- risk assessment of inundation in coastal zones.

SOED has also developed subsurface marine remote sensing methods, such as combining in-situ observations and ship-based laser observations with airborne and satellite lasers to analyze the impact of 3D meso-scale eddies on marine ecosystems. In coastal observations, we have established a 3D integrated observation system encompassing marine, land, and sky through various methods like shoreline-based, remote sensing, ship-based observations, and integration with underwater gliders and marine mooring systems. Significant progress has been made in areas such as HABs, eutrophication, hypoxia, ocean acidification, and in-situ observations of marine  $p\text{CO}_2$ , with results published in top-tier international journals such as *Geophysical Research Letters*. In open ocean regions, combinative use of research vessels, satellites, AUVs, Gliders, BGC-Argo, buoy and deep mooring systems with sediment traps and landers has enabled detailed observations of ecosystems in regions including the South China Sea, the Indian Ocean, Pacific Ocean and the Polar Ocean, yielding significant findings. Here, continuous observations using high-resolution biogeochemical profiling instruments have promoted understanding of the Xianbei Seamount physical-biological coupled response model, with findings published in the top journal *Science Advances*.

From a global to regional scale, and from physical dynamic processes to ecosystem dynamics, SOED has conducted extensive research into ocean physics and ecological modeling. Among these, tracing the pollutants transport across the regions is another key research direction for SOED. Together with marine ecological model simulations and field observations from ships and buoys, we have developed pollutant transport tracking models for the coastal areas of Zhejiang province, aiding in monitoring the health and safety of the marine environment.

Beyond the open oceans and coastal areas, SIO is also a significant participant in Arctic and Antarctica scientific expeditions. Since the first Antarctic expedition on the *Xiangyanghong 10* in 1984, China has conducted 41 Antarctic and 14 Arctic scientific expeditions, establishing five Antarctic research stations in total. China's polar research relies on the icebreakers *Xueloninveveelong 2*, which involves ship-based observations, ice station observations, mooring observations, and satellite remote sensing. China have made numerous advances in studying polar environmental changes, ecosystem responses, and biogeochemical cycles. In 1986, SIO helped establish the Polar Research Institute of China (PRIC), playing a major role in China's polar research endeavors. Our institute has participated in nearly all of China's polar scientific expeditions, with relevant equipment

featured in exhibitions celebrating 40 years of Chinese Arctic and Antarctic expeditions in Beijing, 2024.

China has been actively organizing and participating in international cooperative polar expeditions, and SIO has been engaging in deep cooperation with countries like the USA, France, Germany, and Russia in polar expeditions. A special report by the French National Centre for Scientific Research (CNRS) highlighted SIO's international cooperation with French scientists in the Arctic Ocean. In recent years, SIO has sent five scientists to participate in the MOSAiC project, which is the largest Arctic joint scientific expedition to date. Our scientists deployed self-developed ice-based sediment traps during the MOSAiC expedition, which has laid the groundwork for further studies on the impacts of climate change on the Arctic environment and on China's climate and environment.

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## THE ROSS SEA IN THE CONTEXT OF CLIMATE CHANGE

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**Keywords:** Antarctic Bottom Water, dense shelf water, Ross Sea oceanography, climate variability and forcing, polar sciences

The Ross Sea plays a central role in the Earth's climate system. This region of the Southern Ocean is of fundamental importance for the production of Antarctic Bottom Water (AABW), about 25% of which originates from the Dense Shelf Water (DSW) that forms on the continental shelf<sup>1</sup>, through the release of brine during sea ice formation. The AABW feeds the abyssal layer of the global ocean<sup>2</sup> and thus supplies the lower limb of the global overturning circulation. AABW is able to store heat and carbon in the abyss for several centuries<sup>3</sup> and is thought to regulate the abyssal stratification<sup>4</sup>, the rate of oxygen supply<sup>5</sup>, the atmospheric carbon dioxide concentrations, and thus the Earth's climate on time scales of hundreds to thousands of years<sup>6</sup>. The Ross Sea is also one of the most biologically productive areas of the Southern Ocean<sup>7</sup>, further influencing carbon sequestration and biogeochemical cycles. Recognizing its importance, the world's largest Marine Protected Area (MPA) has been established in the Ross Sea to preserve its ecological and climatological value.

Understanding the long-term variability in the Ross Sea's DSW properties and the mechanisms controlling these variations is crucial to assess the impact on the formation and outflow of AABW and subsequently on the global climate system.

In 2009, the Marine Observatory in the Ross Sea (MORSea), funded by the Italian National Antarctic Research Program, was established to continue the multi-decadal

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<sup>1</sup> ORSI, SMETHIE, BULLISTERR 2002, 107.

<sup>2</sup> ORSI, JOHNSON, BULLISTER 1999, 55-109.

<sup>3</sup> DE LAVERGNE, MADEC, ROQUET, HOLMES, MCDUGALL 2017, 181-186.

<sup>4</sup> HEUZÉ, HEYWOOD, STEVENS, RIDLEY 2013, 1409-1414.

<sup>5</sup> GUNN, RINTOUL, ENGLAND, BOWEN 2023, 537-544.

<sup>6</sup> FERRARI *et al.* 2014, 8753-8758.

<sup>7</sup> ARRIGO, VAN DIJKEN, BUSHINSKY 2008, 1997-2006.

physical and biogeochemical observations collected in crucial areas of the Ross Sea since 1995.

The observatory's efforts have produced the longest continuous oceanographic time series in the Ross Sea, allowing detailed studies of oceanic changes over multi-decadal timescales. MORSea has been a cornerstone for studying the formation and export of AABW, and the variability of DSW properties<sup>8</sup>. Several processes influence the export and properties of AABW.

Tides exert a significant influence on the outflow of dense water from the Ross Sea and the formation of AABW<sup>9</sup>. Recent observations show that dense water pulses occur around the equinox each year, which is due to weaker tides reducing bottom stress and allowing the release of dense water from the Drygalski Trough<sup>10</sup> in the western Ross Sea. Tides, together with the density of water in Terra Nova Bay, can explain much of the variability in the flux and density of DSW from the Ross Sea<sup>11</sup>. The difference in density between Terra Nova Bay and the open ocean is the accelerator, while the tides at the mouth of the trough are the brake. A stronger (weaker) outflow of DSW occurs when the tides are weaker (stronger) and the DSW in Terra Nova Bay has a higher (lower) density<sup>12</sup> a primary source of AABW, shows changes in water properties and volume over the last few decades. Here we show, using multiple years of moored observations, that the density and speed of the outflow are consistent with a release from the Drygalski Trough controlled by the density in Terra Nova Bay (the "accelerator". Long-term tidal cycles, such as the 18.6-year lunar nodal cycle, also modulate the flow and properties of the AABW, causing a change of approximately ~ 30%<sup>13</sup>.

Many studies have shown that the AABW around Antarctica has warmed, freshened and decreased in volume and density in recent decades<sup>14</sup>. The most dramatic changes in salinity and density of the AABW have been observed in the Pacific and Australian Antarctic Basins, which are primarily fed by the Ross Sea DSW<sup>15</sup>. Over the past 60 years, the salinity

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<sup>8</sup> BUDILLON, CASTAGNO, ALIANI, SPEZIE, PADMAN 2011, 1002-1018; CASTAGNO, FALCO, DINNIMAN, SPEZIE, BUDILLON 2017, 37-49; CASTAGNO *et al.* 2019; SILVANO *et al.* 2020; BOWEN *et al.* 202; BOWEN *et al.* 2023, 3873; FALCO *et al.* 2024; ZHANG *et al.* 2024, 8190.

<sup>9</sup> CASTAGNO, FALCO, DINNIMAN, SPEZIE, BUDILLON 2021, 37-49; BOWEN *et al.* 2021; BOWEN *et al.* 2023, 3873.

<sup>10</sup> BOWEN *et al.* 2021.

<sup>11</sup> BOWEN *et al.* 2023, 3873.

<sup>12</sup> BOWEN *et al.* 2023, 3873.

<sup>13</sup> BOWEN *et al.* 2023, 3873.

<sup>14</sup> GUNN, RINTOUL, ENGLAND, BOWEN 2023, 537-544.

<sup>15</sup> GUNN, RINTOUL, ENGLAND, BOWEN 2023, 537-544; SILVANO *et al.* 2020.

of the Ross Sea DSW has decreased continuously and almost linearly<sup>16</sup>, although a rebound in salinity was observed from 2016 to 2019<sup>17</sup>. The freshening is thought to be caused by an increasing imbalance of meltwater available due to thinning of the ice shelves and increased calving of icebergs in the upstream Amundsen and Bellingshausen Seas<sup>18</sup>. The rebound, on the other hand, is attributed to a specific combination of large-scale atmospheric patterns that led to wind anomalies in the Amundsen Sea region and reduced the volume of sea ice imported into the eastern Ross Sea, triggering an increase in local sea ice formation<sup>19</sup>. This mechanism highlights the interconnectedness of atmospheric and oceanic processes and the sensitivity of DSW production and outflow to local and remote climatic forcing. Such variations affect the properties of the AABW, which has global implications for circulation in the abyssal ocean.

Large-scale atmospheric anomalies also directly affect sea ice production in coastal polynyas, altering DSW properties<sup>20</sup> and, consequently, AABW formation rates. A strong correlation was found between the interannual variability of DSW production in the Terra Nova Bay polynya and the leading mode of atmospheric variability in the extratropical Southern Hemisphere (Southern Annular Mode - SAM)<sup>21</sup>. This correlation is most pronounced when the Amundsen Sea Low pressure system is weakened and shifted eastward relative to the Ross Sea. Positive SAM phases amplify offshore winds and lower air temperatures over the western Ross Sea, which increases sea ice production and promotes the formation of DSW, while negative SAM phases have the opposite effect<sup>22</sup>. These dynamics ultimately influence the thickness of AABW in the open ocean. The projected positive trend of the SAM and eastward shift of the ASL have implications for the future formation of DSW and AABW<sup>23</sup>.

These studies show that the Ross Sea is a critical conduit for transferring atmospheric anomalies to the deep ocean, with rapid responses observed in the properties of the dense water. The observed variability of the DSW and AABW underscores the sensitivity of the global climate system to Antarctic processes. Sustained international cooperation is essential for monitoring and understanding these phenomena. Long-term observations and interdisciplinary research will continue to be essential to predict and mitigate the effects of climate change on the Earth's climate system.

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<sup>16</sup> JACOBS, GIULIVI, DUTRIEUX 2022, 1-19.

<sup>17</sup> CASTAGNO *et al.* 2019; SILVANO *et al.* 2020.

<sup>18</sup> JACOBS, GIULIVI, DUTRIEUX 2022, 1-19.

<sup>19</sup> SILVANO *et al.* 2020.

<sup>20</sup> ZHANG *et al.* 2024, 8190.

<sup>21</sup> ZHANG *et al.* 2024, 8190.

<sup>22</sup> ZHANG *et al.* 2024, 8190.

<sup>23</sup> ZHANG *et al.* 2024, 8190.

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## IMPACTS OF GLACIER MELTING ON DOWNSTREAM ECOSYSTEMS

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**Keywords:** glacier meltwater, proglacial lakes, carbon cycling, microbial communities, polar sciences

Global warming accelerates glacier melt, significantly impacting proglacial ecosystems by releasing water, nutrients, and microbes into downstream environments<sup>1</sup>. The Tibetan Plateau, with its vast glacier coverage, plays a critical role in regional hydrology and biogeochemical cycles<sup>2</sup>. The Institute of Tibetan Plateau Research has investigated the seasonal variations in nutrient fluxes, microbial communities, and carbon cycling within the proglacial ecosystems of two Tibetan Plateau glaciers. The focus has been on the dynamic interactions between glacier meltwater, proglacial lakes, and foreland meadows to assess how these processes influence ecosystem function under climate change.

Our long-term field observations, conducted over eight years, reveal that glacier-derived dissolved organic matter (DOM) and nitrate ( $\text{NO}_3^-$ ) inputs vary significantly across seasons, affecting primary productivity and nitrogen cycling in proglacial lakes<sup>3</sup>. Snow-derived DOM, enriched with more bioavailable molecules, enters lakes during spring, while summer melt delivers less bioavailable, lignin-like DOM. Isotopic analysis shows that glacier meltwater contributes approximately 40% of  $\text{NO}_3^-$  to proglacial lakes during the melt season, regulating nitrogen dynamics even during ice-covered winters<sup>4</sup>.

Furthermore, glacier-derived microbes, which account for 20-80% of the microbial community in proglacial lakes, play a pivotal role in shaping microbial diversity and ecosystem functioning<sup>5</sup>. Glacier melting also transforms foreland meadows into methane sources during the melt season, with methanogenic activity increasing due to enhanced organic matter decomposition<sup>6</sup>.

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<sup>1</sup> ROUNCE *et al.* 2023, 78-83.

<sup>2</sup> YAO *et al.* 2022, 618-632.

<sup>3</sup> GUO *et al.* 2025, 652.

<sup>4</sup> WANG *et al.* 2022, 614; XU *et al.* 2025, 272.

<sup>5</sup> LIU *et al.* 2024a, 265; LIU *et al.* 2024b.

<sup>6</sup> XING *et al.* 2024b, 371.

In addition to nutrient and microbial impacts, we explore the potential risks of pathogen and antibiotic resistance gene (ARG) release from glaciers. Our results show low but detectable levels of pathogens and ARGs, highlighting the need for continuous monitoring<sup>7</sup>.

Overall, our findings emphasize the complex and multifaceted impacts of glacier melt on proglacial ecosystems, including nutrient cycling, microbial community dynamics, and potential human health risks, with important implications for future ecosystem management in a warming world<sup>8</sup>.

This study examines the impact of glacier melting on proglacial lakes, the role of meltwater in the carbon cycling of foreland meadows, and the potential health risks associated with the release of microbes and antibiotic resistance genes (ARGs)<sup>9</sup>:

- Microbes and nutrients released from glaciers significantly shape microbial communities and biogeochemical cycles in proglacial lakes.
- Glacier meltwater influences carbon cycling, particularly by enhancing methane emissions in foreland meadows.
- Potential pathogen and ARG release from glaciers require careful monitoring to assess risks to downstream communities.

According to the IPCC, the 21st century has experienced a significant increase in global temperatures compared to pre-industrial levels. On the Tibetan Plateau, warming rates are even more extreme – twice the global average. The Tibetan Plateau holds the largest glacier area outside the polar regions, storing massive water resources in what is known as the “Asian Water Tower”.

Glaciers not only store water but also vast amounts of microbes, viruses, and nutrients. On the Tibetan Plateau alone, glaciers are estimated to contain around  $10^{23}$  cells, 2000 Gg of dissolved organic carbon (DOC), and 500 Gg of nitrogen. As temperatures rise, these glaciers are melting at accelerated rates, especially over the past 40-50 years<sup>10</sup>.

When glaciers melt, water flows into downstream ecosystems—rivers, proglacial lakes, and foreland. Given the Tibetan glacier’s importance as a water source, potential pathogen release is also a public concern. We constructed the first global glacier DNA virus genome dataset and found that viruses on the Tibetan Plateau are mainly bacteriophages<sup>11</sup>. Along with water, bioavailable nutrients and microbes are released, which may benefit oligotrophic downstream ecosystems and arid lands. However, glacier meltwater can also

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<sup>7</sup> MAO *et al.* 2023, 317.

<sup>8</sup> FU *et al.* 2024; LIU *et al.* 2023a.

<sup>9</sup> GOU *et al.* 2025, 178514-178514.

<sup>10</sup> LIU *et al.* 2022b, 2303-2314.

<sup>11</sup> LIU *et al.* 2023b, 2418-2433.

release potentially harmful pathogens, posing a risk to human health<sup>12</sup>. This raises an essential question: is glaciers melting a benefit or a threat? To address this, we focus on two scientific questions<sup>13</sup>: How does glacier melting impact proglacial ecosystems? And do microbes released from glaciers pose risks to downstream communities?

To investigate, we combined field observations with laboratory analyses. We studied multiple glaciers across the Tibetan Plateau and set up two long-term observation stations at Longxiazailongba Glacier and Qiangyong Glacier, focusing on foreland and proglacial lake studies<sup>14</sup>. Since 2015, the Institute of Tibetan Plateau Research has conducted monthly fieldwork, collecting samples from various parts of the glacier basin, including snow, ice, runoff, and proglacial water, and analyzing them for physicochemical properties, nutrients, and microbial content. This work has provided a comprehensive dataset covering these aspects<sup>15</sup>.

Carbon is a crucial nutrient, and while we know glaciers release carbon upon melting, the quality of this dissolved organic matter (DOM) remains largely unknown. Using advanced FT-ICR mass spectrometry, we analyzed DOM in snow, ice, and runoff. Our results show glaciers act as a “DOM filter”: snow-derived DOM, more bioavailable, flows to runoff in spring, while less bioavailable, lignin-like DOM from ice enters in summer. This processed DOM impacts primary productivity in proglacial lakes, with potential implications for regional carbon cycling<sup>16</sup>.

Using oxygen and nitrogen stable isotopes, we estimated that glaciers contribute about 40% of  $\text{NO}_3^-$  to proglacial lakes during melt seasons, influencing nitrogen cycling year-round<sup>17</sup>. Glacial discharge also supplies a substantial microbial community to proglacial lakes, making up 20-80% of their microbial population, according to our eight years of monitoring. This input shapes microbial diversity and interactions, with glacial microorganisms limiting algal growth and impacting lake productivity and carbon cycling<sup>18</sup>.

Interestingly, we found that supraglacial zones transport abundant microbial groups downstream, while subglacial areas contribute more diverse, low-abundance microbial groups. In summary, glacier melt enriches proglacial lakes with nutrients and microbial communities, reshaping ecosystem functions and feedbacks to climate<sup>19</sup>.

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<sup>12</sup> ZHANG *et al.* 2024a, 183.

<sup>13</sup> LIU *et al.* 2022c, 1341-1348.

<sup>14</sup> LIU *et al.* 2024a, 265; LIU *et al.* 2020; XING *et al.* 2024a, 176947-176947.

<sup>15</sup> LIU *et al.* 2024a, 265.

<sup>16</sup> GUO *et al.* 2022, 841.

<sup>17</sup> WANG *et al.* 2022, 614.

<sup>18</sup> LIU *et al.* 2022a, 3791-3805.

<sup>19</sup> ZHANG *et al.* 2024b

Our research also examined the impact of glacier melting on foreland ecosystems and carbon cycling. During summer, glacier melt turns the foreland meadow into a seasonal wetland, influencing soil organic matter decomposition<sup>20</sup>. Using methane flux chambers, we monitored methane emissions before, during, and after the glacier melt season, along with soil conditions and methane-related microbial activity. We found a methane source during melting and a sink during non-melting seasons<sup>21</sup>. Methanogenic gene abundance increased significantly during melt season, as meltwater stimulated decomposition processes that support methanogenesis, turning foreland meadows into methane sources – a concern for global climate change.

Given the Tibetan glacier's importance as a water source, potential pathogen release is also a public concern. We constructed the first global glacier DNA virus genome dataset and found that viruses on the Tibetan Plateau are mainly bacteriophages, with minimal human-related viruses<sup>22</sup>. While nearly 4% of glacier microorganisms are potential Class II pathogens, posing a low risk. They could still lead to infections if transported downstream. We also assessed antibiotic resistance genes (ARGs) and found multiple ARGs in glaciers, with higher concentrations in southeastern Tibet due to greater human impact. Our analysis showed that the risk of pathogenic, drug-resistant bacteria is below WHO's threshold, but ongoing monitoring is needed<sup>23</sup>.

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<sup>20</sup> XING *et al.* 2024b, 371.

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## THE ARCTIC STATION DIRIGIBILE ITALIA: A WINDOW ON THE ARCTIC

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**Keywords:** polar sciences, Svalbard islands, arctic amplification, climate change monitoring

The Arctic Station Dirigibile Italia, one of the research facilities managed by the National Research Council (CNR), is located in one of the most remote and fascinating environments on our planet: the Svalbard Islands. This archipelago, located in the Arctic, is the heart of intense international scientific activity, and CNR is very proud to be part of this important research scene.

The Svalbard Islands are located to the north of mainland Europe, specifically to the north of Norway, and lie between 76° and 80° northern latitude. The village of Ny-Ålesund, where the Dirigibile Italia station is located, sits on the northwestern coast of the archipelago, precisely in the Kongsfjorden, a region of great scientific importance. The Svalbard Islands are affected by the Gulf Stream, which brings warm water from the Equator and influences the climate of the islands. Also, due the presence of this current, climate change is having a much more intense impact in these Arctic regions, a phenomenon known as “Arctic amplification”. This means that temperatures are rising much faster than in the rest of the planet. In fact, the Arctic is warming at a much faster rate than other regions of the world. Over the past 30 years, the average temperature in the Arctic has increased by about 3 °C, a phenomenon that has implications not only for the Arctic environment but for the global climate as a whole. The Svalbard Islands, in particular, are one of the areas experiencing the most significant climate changes, with warming trends being more evident and an acceleration of ice melt processes.

Ny-Ålesund, which today is known as a research village, has an interesting history. Originally a mining village, it was transformed into an international research centre in the 1960s. Today, Ny-Ålesund is a globally important scientific hub where researchers from 12 different countries, including Italy, China, Germany, the UK, France, and many others, conduct studies on various aspects of the Arctic environment. In particular, Italy (through the CNR, and China, via the Chinese Polar Research Institute) are conducting significant research in this region. The village of Ny-Ålesund is managed by a Norwegian company and is very well connected to the rest of the world, thanks to regular flights linking it

to mainland Norway and from there to international destinations. This makes the village easily accessible to researchers from all over the world who can come and conduct their scientific investigations in this extraordinary region.

Dirigibile Italia is a multidisciplinary station supporting a wide range of national and international scientific projects. Founded in 1997, the station is dedicated to advancing research on the Arctic environment and monitoring climate change. The station is named after the *Dirigibile Italia*, commanded by General Umberto Nobile, which in 1928 attempted an epic mission to fly over the North Pole. This venture remains a symbol of courage and technological innovation, and the station is a tribute to that scientific attempt. The station is equipped with a series of scientific laboratories, advanced equipment, and specialized transportation means to support both field research activities and sample pre-analysis. Scientific activities at the station have grown significantly over the years. Since 2010, with the expansion of research infrastructures, the station has seen a considerable increase in the scope of projects carried out. Thanks to the efforts of the CNR, new research facilities have been installed that have greatly improved our ability to monitor the environment and collect real-time data. Since 2018, thanks to the Arctic Research Program funded by the Italian Ministry of University and Research, scientific activity has further increased, with numerous projects monitoring the climate, the cryosphere, marine and terrestrial ecosystems, and much more. In 2020, research activities were inevitably impacted by the global COVID-19 pandemic, which slowed down some operations. However, despite the challenges, we managed to maintain many of our monitoring operations.

The scientific topics addressed at our station cover a broad spectrum of disciplines related to environmental sciences and climate change. Among these, research on the atmosphere, particularly the chemistry and physics of the air, is of great importance. Additionally, the study of the cryosphere, including the study of sea ice, glaciers, and permafrost, is one of our priority research areas. Marine and terrestrial biology is another area where we are particularly active, studying the ecosystems that inhabit both the Arctic lands and seas. Oceanography, with a special focus on ocean currents and salinity, is also crucial. We also monitor Earth from space, studying the interaction between our planet and the Sun, as well as cosmology and astrophysics.

In 2010, the CNR implemented new research infrastructure around Ny-Ålesund to further support the station and its scientific projects. Among these infrastructures are instrumented moorings that have been installed in nearby fjords and along the southwestern coast of the islands<sup>1</sup>. These devices continuously measure various environmental parameters at different depths. Among the parameters monitored are water temperature, salinity, ocean

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<sup>1</sup> D'ANGELO *et al.* 2018, 5343-5363.

currents, dissolved gases, acidity, and other crucial factors for understanding the changes occurring in the Arctic marine environment. The moorings are also capable of collecting sediments and pollutants, including microplastics. This data is essential for understanding changes in the Arctic seas, which are among the most vulnerable to the effects of global warming. Another key research infrastructure at the station is the Climate Change Tower, which, with its 34 meters, is one of the most advanced monitoring tools in the region<sup>2</sup>. The tower is equipped with atmospheric sensors that measure the energy exchanged between the atmosphere and the underlying Earth's surface. The data collected helps improve our understanding of the changes taking place in the Arctic, an area where global warming is particularly accelerated. In addition to these activities, the CNR is also involved in the continuous monitoring of atmospheric composition, with particular attention to aerosol particles and emerging pollutants<sup>3</sup>. These studies are essential for understanding how changes in atmospheric conditions impact the Arctic environment and, ultimately, the entire planet. Another important aspect of the activities at our station is the monitoring of snow<sup>4</sup>. It is continuously monitored collecting data on physical parameters, such as density, humidity, and temperature. Weekly and annual sampling of the snowpack is also conducted, and during specific drilling campaigns, snow and ice cores are taken for analysis.

Finally, it is important to highlight that Dirigibile Italia participates in several international transnational access programs, which allow researchers from all over the world to conduct their activities at our base. These programs are essential for advancing Arctic science and strengthening international cooperation in environmental research.

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<sup>2</sup> MAZZOLA *et al.* 2016, 7-18.

<sup>3</sup> UDISTI *et al.* 2016, 85-94.

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## THE PNRA'S FACILITIES IN ANTARCTICA

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**Keywords:** Italian national Antarctic program, polar research infrastructure, polar sciences, Antarctic logistics and operations, Antarctic research stations

### 1. Introduction: The Italian National Antarctic Program

Italy is present in Antarctica since 1985 with the Italian National Antarctic Research Program (PNRA), a governmental program approved and funded by the Ministry for the University and Research (MUR).

PNRA has built two scientific stations in Antarctica: “Mario Zucchelli” station, located along the coast of northern Victoria Land and open only during the summer season, from November to February, and “Concordia” station, located on the eastern Antarctic plateau, in the Dome C site, over 1200 km from the coast. Concordia station was built and is managed together with French Polar Institute and is open throughout the year.

Italy has joined the Antarctic Treaty (Washington 1959) in 1981, and in 1987 has gained the status of Consultative Party, with the right to vote. In 1988 Italy became a Full Member of the Scientific Committee on Antarctic Research (SCAR). Italy is also part of the Council of Managers of National Antarctic Programs (COMNAP).

The Italian PNRA operates through the Scientific Committee for the Antarctica (CSNA) sets the strategic lines and evaluates the scientific projects; the National Research Council (CNR), which has the role of scientific coordination, and the Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), which is in charge of all the operations in Antarctica. The National Institute of Oceanography and Apply Geophysics (OGS) is in charge for naval operation by means of the research vessel Laura Bassi.

CNR, ENEA, OGS, Universities and other scientific Institutions participate with their personnel to PNRA expeditions. The Ministry of Defence contributes with specialists from the Army, the Navy, and the Air Force.

The National Museum for the Antarctica (MNA), which has three seats located in Genoa, Siena, Trieste, preserves samples and enhances the findings obtained during the scientific expeditions.

## 2. Mario Zucchelli Station

Mario Zucchelli Station is located in Terra Nova Bay's, 74°42'S, 164°07'E, on the Ross Sea coast, at 15 meters a.s.l. It is open from mid-October to mid-February, when the temperature ranges from -25°C to +5°C. The official time is GMT+11.

MZS is connected to New Zealand by ship and aircraft and represents an important hub in the Ross Sea Region area where are located Jang Bogo Stations (KR), Qinling (PRC), Gondwana (DE), McMurdo (USA) and Scott Base (NZ). In the Antarctic Treaty spirit, PNRA keeps up fruitful logistical and scientific cooperation with all of them and other National Programs too.

Concerning aircraft support, two helicopters are chartered full season and overwinter at the station. A Basler BT-67 is chartered for the summer season. The Station can accommodate 124 people max, with an average presence of 85. 40 marine and land vehicles are available. The Station is equipped with science laboratories, an aquarium and several warehouses and workshops. Self-sufficiency is ensured by several facilities (electrical generator, desalter for drinkable water from sea water, incinerator and a sewage treatment plant).

PNRA's research program covers terrestrial and marine domains in the area, as well as biology, chemistry, seismology, physics of atmosphere, astronomy, climatology and geology. It also includes long-term observational activities such as a network of meteorological facilities; ionospheric activity monitoring; seismic, permafrost evolution, magnetic and GPS networks.

An important logistical facility present in MZS is the new gravel runway located in Boulder Clay, a site 4 km far from the Station. The runway can operate with intercontinental aircraft such as the Hercules C130 and intracontinental aircraft such as Basler. Its presence facilitates operations to the Northern Victoria Land and increases the safety conditions on the whole Ross Sea Region area. The strip is 1.750m in length and 60m width with a parking area of 140x140m.

## 3. Concordia Station

Concordia Station is located in Dome C (75°06'S 123°21'E) on the Antarctic plateau, at 3233 metres a.s.l and 1200 km far from the coast. In the winter period the temperature falls below -80°C. The official time at the Station is GMT+6.

The station has been built and is managed together with the French Polar Institute (IPEV). The IPEV ensures the supply of heavy loads by land, through convoys of tracked vehicles (Traverse), while the PNRA guarantees the air transport of personnel and light cargo. Concordia has been inhabited nonstop since 2005. In the summertime, from November to February, it can host an average of 65 people, while in the wintertime a crew of 12 to 16 keep the station operational.

Concordia is considered as the ideal location for astronomical observations and for studying the cryosphere-atmosphere interactions, and the seismological recording. The total seclusion and the harsh conditions make Concordia a laboratory to simulate the problems of surviving in a space vehicle. Biology and medicine studies aimed at understanding man's adaptation to the hostile environment are also performed.

#### **4. RV Laura Bassi Icebreaker**

Laura Bassi is an icebreaking research vessel operated by the Italian National Institute for Oceanography and Applied Geophysics of Trieste. It is available for the scientific community and has been used by PNRA since 2019 for both scientific and logistic purposes.

Laura Bassi is the only Italian ship certified for sailing in polar waters. Its small size (tonnage 4028 t, length 80 m, width 17 m) and the dynamic positioning system "DP2" provides high maneuverability and positioning accuracy that are suitable for scientific research. The hold of the vessel has a total volume of 3.000 m<sup>3</sup> and the cargo capacity is around 26-30 containers (approx 800 t) also considering the deck. Laura Bassi has a dedicated fuel tank for Jet A1 of approximately 180 m<sup>3</sup>.

The icebreaking is equipped with two laboratories, two cranes and a flight deck for helicopters. It has got 37 cabins where they can accommodate a maximum of 50 passengers and 22 crew members.

In February 2023, the RV set a record by sailing further south than any ship before, achieving 78°44,280'S in the Bay of Whales, which was made possible by an unusual lack of ice.



## **BIOGRAPHIES**



## KEYNOTE SPEECHES

### **Oliviero Diliberto**

Oliviero Diliberto (Cagliari, 1956) is a full professor of Institutions of Roman Law and Foundations of European Law at the Faculty of Law, Sapienza University of Rome, where he also serves as Dean. Additionally, He is the Dean of the School of Economics and Law at Zhongnan University of Economics and Law in Wuhan, China, where he has been the “Wenlan” Chair Professor since 2016. He has authored over 200 publications on the history of Italian and international legal institutions and the relationship between contemporary legal science and emerging technological and scientific innovations. Among his notable contributions is his work on editing the Italian translation of the Chinese Civil Code (2021, 2023) by Huang Meiling. Diliberto was an Italian parliamentarian from 1994 to 2008 and served as Minister of Justice from 1998 to 2000. On September 30, 2024, he was honored with the Chinese Government’s Friendship Award, the highest recognition given to foreign experts by the Chinese government.

### **Cui Peng**

Cui Peng holds a Ph.D. in engineering. He is a professor and doctoral supervisor at the Institute of Mountain Hazards and Environment, Chinese Academy of Sciences (CAS), and is an academician of the Chinese Academy of Sciences. Prof. Peng Cui is an expert in physical geography and soil and water conservation and receives a special government allowance from the National Council. Prof. Peng Cui was selected for the “New Century National Hundred, Thousand, and Ten Thousand Talents Project” and is recognized as an academic and technical pioneer in Sichuan Province. Currently, Prof. Peng Cui serves as the Co-Chair of the Alliance of International Science Organizations on Disaster Risk Reduction (ANSO-DRR) under the Belt and Road Initiative, the Executive Deputy Director and Chief Scientist of the China-Pakistan Joint Research Center on Earth Sciences, and Director of Sino-Italian Joint Laboratory on Geological and Hydrological Hazards. He was previously the chief scientist of the National 973 Program, a representative of the 13<sup>th</sup> National People’s Congress, a deputy leader of the General Group for Line and Station Planning in the Expert Advisory Committee for the Sichuan-Tibet Railway Construction, and a member of the International Scientific Committee of the Integrated Research on Disaster Risk (IRDR) program of ISC/UNDRR. Prof. Peng Cui also advanced key technologies for disaster risk reduction in mountainous communities, roads, and scenic regions, forming a comprehensive disaster mitigation technology system. The research fruits have been successfully applied in major disaster response and risk control practices, including the

Wenchuan earthquake, Zhouqu debris flow, Venezuela debris flow, Pakistan dammed lake, and Nepal earthquake. Consequently, these efforts significantly contributed to risk control and mitigation work and were recognized by international peers and governments.

## FORUM 1

### **Andrea D'Andrea**

Andrea D'Andrea is Associate Professor at the University of Naples "L'Orientale". He has participated in numerous archaeological missions in Italy and abroad (Saudi Arabia, Cyprus, Egypt, Ethiopia, Jordan, Oman, Turkey, and Yemen), focusing on topographic and three-dimensional surveys. He has coordinated several research projects on the application of digital technologies to cultural heritage.

He is the author of two monographs on archaeological documentation, editor of four collected volumes, and has published more than 140 scientific papers.

Since 2022, he has been the leader of Work Package 10 (WP10) within the *Retina* project, part of the *ITSERR* initiative funded by the Italian National Recovery and Resilience Plan (PNRR). From 2015 to 2016, he served as Scientific Director of *The Great Pompeii Project*, supported by the Archaeological Park of Pompeii.

Between 2012 and 2015, he was the Scientific Coordinator for the University of Naples "L'Orientale" within the European project *3DICONs* (3D Digitisation of Icons of European Architectural and Archaeological Heritage, Grant Agreement No. 297194, CIP-ICT-PSP-2011-5).

From 2010 to 2021, he was Principal Investigator of the project *3D Surveys and Reconstruction of the Solar Temple of Niuserra*, developed in collaboration with the Italian Ministry of Foreign Affairs and the Supreme Council of Antiquities of Egypt.

### **Yi Tong**

Yi Tong, Research professor. Director of the Institute of Innovation for Development, BJAST. Deputies to the 13<sup>th</sup>&14<sup>th</sup> National People's Congress. Mrs. Yi has long been devoted to the research of Regional innovation system and Culture & Technology Integrated Development. She has chaired more than 80 research projects commissioned by government institutions at various levels and has published 60 research papers. She has participated in the compilation and publication of more than 20 monographs and has won over 20 science and technology awards at ministerial level.

## **Peng Jian**

Peng Jian is a distinguished researcher at the School of Cultural Industry Management, Communication University of China, and serves as a Master's Supervisor and Secretary-General of the Institute for Cultural Development and Communication. A visiting scholar at Peking University's School of Economics, he consults for the International Cooperation Center of the National Development and Reform Commission. Dr. Peng is a training expert for the Ministry of Industry and Information Technology and holds leadership roles in cultural and health associations.

Previously, he was a journalist for CCTV, a planning director at Xinhua News Agency, and held executive positions in public relations and performance management. An accomplished academic, he earned his DBA from Macau University of Science and Technology and EMBA from Tsinghua University. Dr. Peng has published four books, edited a dictionary, 13 yearbooks, and over 35 articles. His 11 research reports have been influential in shaping national policies.

## **Daniele Spizzichino**

Daniele Spizzichino holds a degree in Environmental Engineering from the University of Rome (1999). He got the PhD on Earth System Sciences: Environment, Resources and Cultural Heritage at Modena and Reggio Emilia (2012). Daniele has developed a very strong expertise in ICT (e.g. hydrological risk analysis, digital maps on natural risk elaboration, Earth Observation, GIS, geo-hazard and risk assessment, geotechnical modelling) applied to cultural heritage protection domains. He has worked and coordinate, as a researcher and professional consultant, several research team work. Since 2000 his geotechnical engineering skills has been especially addressed to: executive design of Cultural Heritage low impact mitigation measures; monitoring system implementation (e.g. remote sensing, satellite and traditional topographical network), natural hazard risk assessment and protection plan for Natural and Cultural Heritage. In particular, he has been extensively supporting national and international organizations (e.g. UNESCO, WMF, ICOMOS) in several research projects of the World Heritage sites such as: (Machu Picchu) Peru, (Aksum, Lalibela) Ethiopia, (Tiwanaku) Bolivia, (Ester Island) Chile, Georgia (Vardzia and David Gareji), Armenia, Jordan (Petra), (Bamiyan Valley) Afghanistan, (Lumbini and Katmandu) Nepal, Madagascar (Antananarivo), (Pompei, Tarquinia and Roma) and many others. Author and co-author of more than 150 publications and books. He has published several articles in scientific journal, papers and conference proceedings. He is a member of many associations (ICOMOS, AGI (TC301), ICL, IAEG, vice president of the Blu Shield Italian comitte). He is currently employed – as senior researcher - at ISPRA, Dept. for the Geological Survey

of Italy, elected member of the scientific board of the institute and adjunct professor to the UNESCO Chair on prevention and sustainable management on Geo-Hydrological Hazards.

### **Min Xiaolei**

Min Xiaolei, associate researcher and assistant professor at the School of Design in Hunan University, member of the key laboratory “Digital Cultural Creation and Intelligent Design Technology” of the Ministry of Culture and Tourism in China, and a post-doctoral fellow at the Yuelu Academy (already finished). Her research interests include the integration of culture and technology, digital cultural innovation, and cultural ecology of intangible cultural heritage. She has presided over a number of key projects, such as the Youth Fund for Humanities and Social Sciences of the Ministry of Education, the Postdoctoral Science Fund, and the Research on Science and Technology Development Strategy of the Chinese Academy of Engineering. She has published more than ten papers in the core journals of design, such as Journal of Nanjing Academy of Arts, Decoration, Fine Arts Observation, and the 32<sup>nd</sup> World Design Assembly (held by WDO), UNESCO International Symposium on Heritage Conservation, and other high-level international conferences. She has organized and participated in international exhibitions such as Milan International Handicrafts Exhibition, Paris International Exposition, the UNESCO Saint-Etienne International Design Biennale, and so on. She was awarded the First Prize of Hunan Provincial Social Science Outstanding Achievement Award, the Second Prize of Outstanding Paper of Hunan Provincial Social Sciences Academic Annual Meeting, and the Third Prize of National Characteristic Cultural Industry Summit Forum.

### **Francesco Novelli**

Francesco Novelli, architect, Ph.D., Specialist in *History, Analysis, and Evaluation of Architectural and Environmental Heritage*, is an Associate Professor of Restoration at the DAD, Department of Architecture and Design of the Politecnico of Torino. He teaches theoretical courses and design studios in the Bachelor’s and Master’s degrees in Architecture. Since 2021, he has been a Visiting Professor at the South China University of Technology (SCUT) in Guangzhou – China. Since 2024, he has been Director of the Areas of Architecture of the ‘China Centre’ of the Politecnico of Torino. He carries out research on topics concerning the restoration of architectural heritage, the protection and conservation of religious and fortified architectural heritage, and the refunctionalization and enhancement projects in complex restoration interventions. Among his most recent publications are monographs and scientific essays on the themes of conservation and restoration of the

religious architecture of Bernardo Antonio Vittone, the re-functionalization and valorization of abandoned or underused religious architectural heritage, and the planned conservation programs for systems of publicly owned assets. He has designed and directed numerous restoration interventions.

### **Wang Xiaoyu**

Wang Xiaoyu, PhD, is Professor and Dean of the College of Fine Arts at Zhengzhou University. He serves as a member of the Teaching Guidance Committee for Design Disciplines under the Ministry of Education of China, and as a member of the Graphic Design Art Committee of the China Artists Association.

He is also Director of the Design Education Specialized Committee of the China Higher Education Society and a Director of the Henan Province Artists Association.

Prof. Wang has been recognized as an *Outstanding Teacher of Henan Province* and *Outstanding Teacher in the Education System of Henan Province*. He was the first scholar from Henan Province in the field of design to be awarded a National Scholarship Fund Visiting Scholarship.

He currently also holds the position of Deputy Secretary-General of the Henan Province Association for PhDs in Fine Arts and Design.

### **Teresa Guaragnone**

Teresa Guaragnone holds her Ph.D. in Chemistry (curriculum in Science for Cultural Heritage) at the University of Florence in 2021 and is currently working as a postdoctoral researcher at the same institute. Since 2017, her research is focused on the characterization of the interactions between nanostructured fluids and unwanted layers on artistic surfaces and on the development of new innovative hydrogels for cleaning modern and contemporary art. She was part of the research team involved in the European projects Innovaconcrete and GreenArt, dedicated to the formulation of green materials for the conservation of works of art. She is currently involved in managing the project “CSGI-Solution for Conservation of Cultural Heritage”, aimed at creating an innovative start-up to bring university-developed formulations to the market.

### **Jiang Guanghua**

Jiang Guanghua, Ph.D., researcher at the Innovation and Development Strategy Research Institute of Beijing Academy of Science and Technology. Mrs. Jiang has long been devoted to the research of Culture & Technology Integrated Development, cultural industries, and

technology policies. She has chaired and participated in more than 60 research projects. She has published over 40 academic papers and participated in the writing and publication of more than 20 monographs. She has won over 10 various science and technological awards.

### **Shen Dawa**

Shen Dawa is a senior conservation scientist of China Academy of Cultural Heritage. She graduated from Institute of Chemistry, Chinese Academy of Science in 2005, with PhD of nature science, then joined China Academy of Cultural Heritage. From 2015.10-2016.9, she worked in CNR- IVALSA, Italy as a visiting scholar. Research area includes conservation of organic cultural relics, and analysis and characterization of cultural relics. In recent years, she has been working on conservation of waterlogged archaeological wood and bamboo. She participated several shipwreck conservation projects of China, including Nanhai I, Huaguangjiao I and Quanzhou Ship. She has more than 20 journal articles published with the first author. She is also the translator of the Chinese version of two books, “Conservation of Archaeological Ships and Boats- personal experiences” and “Preserving Vasa”.

## **FORUM 2**

### **Michelangelo Pascale**

Michelangelo Pascale is Graduated in Chemistry at the University of Bari (Italy). He has been researcher at the Institute of Sciences of Food Production (formerly Institute of Toxins and Mycotoxins from Plant Parasites) of the National Research Council of Italy. Since 01/02/2021 he is Director of the Institute of Food Sciences of the National Research Council of Italy. He has many years of experience in the field of food safety, mainly on mycotoxins. He has conducted researches on the toxigenicity of fungi of agro-food interest, on the occurrence of mycotoxins in food products, on the effect of fungicides on cereal diseases and mycotoxin accumulation, on the effect of industrial-scale cleaning processes on the reduction of mycotoxins in cereals, on the effect of food processing on mycotoxins, on the evaluation of new post-harvest strategies to reduce mycotoxin levels, on the development and validation of analytical methods for mycotoxins determination in food, feed and biological fluids and analytical methods for assessing food authenticity. Author of 122 publications in peer-reviewed journals, since 2020 is co-Chair of the ILSI Europe Food Contaminants Task Force.

### **Claudia Zoani**

Researcher at the ENEA Sustainable AgriFood Systems Division, graduated in Chemistry with a PhD in Analytical Chemistry, she concluded the research activities of a second PhD in Agriculture, Food and Environment. She conducts R&D activities on Reference Materials and Methods; measurement uncertainty; food quality, safety and traceability; sustainability of agrifood systems; chemical risk assessment. Scientific Secretary of the IMEKO TC23 Metrology in Food and Nutrition and member of the Eurachem WG on Reference Materials and UNI Committee General Metrology. She is the Coordinator of the Research Infrastructure METROFOOD-RI, currently funded under the HEu project METROFOOD-EPI, and engaged as PI for ENEA in several national and European ongoing projects, such as the HEu AgroServ, DGR4Food, FHERITALE and EOSC-Beyond. In the frame of the Italian NRRP funded by NextGenerationEu, she coordinates the project METROFOOD-IT, focused on “Strengthening of the Italian RI for Metrology and Open Access Data in support to the Agrifood” ([www.metrofood.it](http://www.metrofood.it)).

### **Chiara Nobili**

With a degree in Chemistry and a PhD in Botany, is a researcher at ENEA. She has scientific expertise related to the sustainability, quality, safety, and competitiveness of agrifood production systems. She has contributed to the strengthening of METROFOOD research Infrastructure in the field of quality and reliability of chemical and biological measurements, as well as the sharing of data, information, and metrological tools, to promote knowledge and scientific excellence in food quality & safety.

Regarding the efficient management of resources and the circularity of production processes, to support the implementation of circular economy policies and good practices, she has carried out research activities relating to the development of food production from a circular perspective. She coordinates consolidation and promotion activities of the Italian Platform of actors for the Circular Economy ICESP regarding the developing and implementation of circular biotechnologies.

### **Zhao Gang**

Zhao Gang is former Vice President of Chengdu University and Director of the Key Laboratory of Coarse Cereal Processing, Ministry of Agriculture and Rural Affairs. He has led over 20 major national and provincial research projects, published 200 papers, with more than 100 included in SCI journals, and served as chief editor for eight monographs including “Chinese Buckwheat Science.” He holds 38 invention patents and has developed

and promoted eight new coarse cereal varieties. His projects have won nine provincial and ministerial Science and Technology Progress Awards and six national or provincial teaching achievement awards. Honors include Sichuan Province Outstanding Teacher, Outstanding Expert with Significant Contributions, Academic and Technical Leader of Sichuan, State Council Special Allowance, National Buckwheat Industry Lifetime Achievement Award, Chengdu Advanced Individual for Reform and Innovation, and Chengdu Model Worker.

### **Silvana Cavella**

Silvana Cavella is full professor of Food Science and Technology at the Department of Agricultural Sciences -University of Naples Federico II. Teacher of the courses in *Food Unit Operations* and *Food Engineering and Elements of Food Packaging*. Main research topics concern food structure and physical properties, sweeteners, wheat flour dough, food gels and oleogels, sensory analysis and consumer science, food processing and preservation technologies.

### **Zhao Jianshe**

Zhao Jianshe is a research fellow and currently serves as the director of the Henan Zhongyuan Organic Agriculture Research Institute and the head of the Henan International Joint Laboratory. He has long been dedicated to the innovation and integrated application of key technologies in organic & ecology farming. His research covers multiple areas, including ecological agriculture, organic vegetables, and seeds. He has successively led and participated in 8 provincial and municipal scientific and technological projects, as well as international cooperation projects, receiving 11 provincial and municipal science and technology awards. His experience shared as typical case studies at the 20th World Organic Conference and the 4th Asian Organic Conference. He has been honored with titles such as Excellent Science and Technology Commissioner in Henan Province, and Excellent Science and Technology researcher in Henan Province. He currently operates a farm of over 110 hectares in Henan Province, China, where he has developed a series of ecological cultivation methods suitable for local climate and soil characteristics. Through crop rotation, intercropping, and scientific fertilization and irrigation management, he has successfully improved soil fertility and biodiversity. In 2023, the farm was recognized as a China national-level ecological farm in China.

### **Mauro Centritto**

Mauro Centritto obtained his PhD at the Faculty of Science and Engineering, University of Edinburgh. Dr. Centritto is currently directing the ENI-CNR Joint Research Center

“Water - Hypatia of Alexandria”. He is the former director of the Trees and Timber Institute - National Research Council of Italy (CNR) and of the Institute for Sustainable Plant Protection-CNR. He has international experience in biosphere-atmosphere interactions and over 35 years’ experience in collaborative eco-physiological research on climate change impact on plant growth and physiology in relation to dry environments. He is currently Panel Member of the UNCCD-CSO representing Western Europe and member of the Steering Committee of DesertNet International. Dr. Centritto seats in the Doctorate Board Ph.D. Program in Agricultural Science of the University of Sassari and served in the “Tang Prize Selection Committee”, prize category *Sustainable Development*. He serves in the editorial board for different plant scientific journals. Dr. Centritto has coordinated several national and international projects.

### **Andrea Armani**

Andrea Armani is a Full Professor in the Department of Veterinary Sciences at the University of Pisa (Italy), where he also leads the FishLab – a laboratory dedicated to the biotechnology of food inspection, with a particular focus on the safety and traceability of fishery products. His research specializes in food authentication and food legislation. Armani holds a DVM and PhD, his research centers on food authentication and food legislation, employing molecular techniques such as DNA barcoding and metabarcoding to detect species substitution and fraud in various food products, including seafood, mushrooms, and insect-based foods. Armani has authored over 140 scientific publications and serves on the editorial board of the journal *Food Control*.

### **Hu Jiajie**

Hu Jiajie is a Ph.D. student in the Department of Veterinary Sciences at the University of Pisa (Italy). His research focuses on the application of atmospheric cold atmospheric plasma for microbial inactivation and the use of next-generation sequencing technologies in food authentication. He graduated in “Food Science and Engineering” in Zhejiang Ocean University, Zhoushan (China).

### **Ying Xiaoguo**

Ying Xiaoguo is an Associate Professor at the College of Food and Pharmaceutical Sciences, Zhejiang Ocean University, China. His main research interests include the processing and preservation, and cold-chain logistics of aquatic products, particularly prefabricated seafood dishes and smart packaging technologies. He holds a Ph.D. from the University

of Pisa and completed a postdoctoral fellowship at Zhejiang University. Dr. Ying has led and participated in numerous national and provincial scientific projects, including those funded by the National Natural Science Foundation of China and the Zhejiang Provincial Department of Science and Technology.

### **Yolande Thérèse Rose Proroga**

Yolande Thérèse Rose Proroga is a veterinarian and Food Microbiology Laboratory Manager specializing in Official at Experimental Zooprophyllactic Institute of Mezzogiorno. Over the years, she has developed extensive expertise in food microbiology, biotechnology, and food safety. As the Manager of the Food Microbiology and Biotechnology Laboratory at IZS Mezzogiorno, Proroga oversees laboratory operations, ensures ISO 17025 compliance, and acts as a liaison for national reference centers on foodborne pathogens and GMOs, serving as a technical consultant for competent authorities, where she provides support in public investigations related to food safety. Proroga is a member of the National Working Group on Microbiological Criteria (IIZZSS), dedicated to studying diseases and farming insects for food production, as well as microbiological food control, a coordinator of National Working Group on Microbiological Criteria (IIZZSS), a delegate of the UNI Standards Committee, contributing to the development of microbiological standards for the agri-food sector and collaborating in ISO working groups on Salmonella detection, enterococci enumeration, and sterility testing. She contributes as an external expert for the EU-funded RaDAR project, focused on the development of antimicrobial resistance (AMR) detection systems, and she is the contact person for IZSM at Italy's Focal Point for EFSA, they provide expertise on: Genetically modified organisms (GMOs), biological hazards, human nutrition, dietetic products, allergens and/or novel foods and Emerging Risks. Proroga works as a European Commission TAIEX Expert, delivering training on the analysis of GMOs, Norovirus, and Hepatitis A virus, and facilitating workshops in countries such as Morocco and Jordan. Academic and Scientific Contributions. Proroga is actively involved in veterinary association committees, supervises research projects, and frequently presents at conferences and training sessions. She has authored 62 peer-reviewed publications (H-index 20) and continue to contribute to scientific advancements while serving as an expert advisor in public competitions. In addition, she serves on the editorial boards of *Frontiers in Microbiology* and *Foods*, contributing as a reviewer and guest editor on food safety topics. She is also the co-inventor of a patent on the use of ultra-nanoclusters for food preservation (2021).

## FORUM 3

### **Stefano Pignatti**

Master degree in Geology at the University of Rome “La Sapienza” in 1988. Since 1995 he is a research scientist researcher at the National Research Council of Italy and since 2020 he is Research Director at the Institute of Methodologies for Environmental Analysis (CNR IMAA). He is expert in optical radiometry, in particular to the visible-shortwave and thermal infrared spectroscopy from proximal to airborne and satellite platforms. He has developed validation sites in Italy for determining the absolute radiometry of airborne and spaceborne mid and thermal infrared radiometers.

A key aspect of his research is the development of new techniques to analyse and extract critical information from optical remotely sensed data, in particular to assess the maturity of primary products for soil, agriculture and raw materials.

Since 2017 he is actively working with Chinese colleagues on research projects dealing with the combined exploitation of European and Chinese Earth Observing data for retrieving surface bio-geophysical parameters. He is actually leading, supported by the National Research Centre (CNR) and the European Space Agency, with the Ministry of Science and Technology of China (MOST) and Chinese Academy of Science (CAS) collaborative research projects on pest and diseases and food security in the framework of the Climate Changes themes.

### **Luigi Fiorentino**

Luigi Fiorentino graduated in Law and obtained a Postgraduate Diploma in Administrative Law and Administrative Science from the University of Naples. He serves as a Counselor in the role of the Presidency of the Council of Ministers. He is an Adjunct Professor at the Department of Social and Economic Sciences at the University of Rome “Sapienza,” where he teaches *Public Organizations and Sustainability* in the Applied Social Sciences degree program. He also teaches *Organization and Management of Public Administrations* at LUISS Business School. He has carried out academic activities at the Administrative Law Chair of the University of Rome “La Sapienza” (Prof. Sabino Cassese). In 2003, he was a Jemolo Fellow at Nuffield College, Oxford. He is President of the “Guido Dorso” Research Center and serves as the scientific-editorial coordinator of the *Italian Journal of Public Management*. Additionally, he is an external member of the Board of Directors of the Sant’Anna School of Advanced Studies. He is a member of the International Academy for Economic and Social Development (AISES). He is the author of numerous publications on various topics related to administrative law and collaborates with specialized journals.

## **Yang Shuo**

Yang Shuo is an Associate Professor at Zhengzhou University of Technology. She received her Doctorate in Chemical Engineering, specializing in risk and resilience assessment, from the Polytechnic University of Turin between November 2020 and July 2024. Dr. Yang's research primarily focuses on risk assessment for socio-technical systems and urban resilience. One of her key research areas involves the use of Natural Language Processing and causality model building based on data from accident reports to improve risk management and understanding. Another important direction of her work is Agent-Based Modeling and Simulation, where she analyzes the performance of complex human-robot collaboration systems to optimize their efficiency and safety. Additionally, Dr. Yang conducts research on city resilience, developing frameworks and strategies to enhance the resilience of urban environments against various risks.

Before joining Zhengzhou University of Technology, Dr. Yang worked as an Associate Researcher at the Chinese National Institute of Standardization from July 2011 to September 2020. During her time there, she coordinated the development of more than ten national standards in the field of public service standardization. Her efforts were particularly focused on elder care services, railway transportation services, government services, and service quality management. Dr. Yang's research bridges academic inquiry and practical application, positioning her as a leading figure in her field.

## **Gianmaria Sannino**

Gianmaria Sannino is a climate scientist holding a Ph.D. in Marine Science and Engineering from the University of Naples Federico II. Since 2022, he serves as the Director of the ENEA Division for "Models, Observations, and Scenarios for Climate Change and Air Quality." From 2015 to 2022, he led the ENEA Climate Modeling and Impacts Laboratory, advancing research on climate science and environmental impacts. Throughout his career, Dr. Sannino has coordinated both national and international projects addressing climate change and marine energy production. His expertise is frequently sought for research evaluations by esteemed organizations such as the Italian National Agency for the Evaluation of Universities and Research Institutes, the French National Research Agency, the Dutch Research Council, and the European Commission. He is an active member of the Scientific Committee for Marine Renewable Energy within the European Energy Research Alliance and represents Italy in the Strategic Energy Technology Plan's Working Group on Ocean Energy. Additionally, Dr. Sannino contributes as a member of the Technical Scientific Committee for the BIG-Blue Italian Growth Cluster, represents ENEA within the European Global Ocean Observing System, and participates in the Italian Oceanographic Commission.

### **Alessandro Anav**

Alessandro Anav is a permanent researcher in the climate modeling laboratory at ENEA. He holds a Master Science Degree in Environmental Sciences and a Ph.D. in Forest Ecology. He has a strong background in regional climate modeling.

From 2009 to 2011 he was post-doctoral fellow at Laboratoire de Météorologie Dynamique (France), from 2011 to 2015 he worked as research fellow at University of Exeter (UK), then he worked as post-doctoral fellow at Institute for Sustainable Plant Protection (Italian National Research Council).

Current research activities mostly focus on the development and application of regional coupled ocean-atmosphere models. Additional research interest is also focused on the global carbon cycle and its interaction with the climate system as well as on the use of chemistry transport models to simulate air quality and assess the impact of air pollution on human and ecosystems health.

He is author of 60 peer reviewed publications on international journals, and he contributed to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) published in 2014.

### **Franco Catalano**

Franco Catalano is permanent researcher at ENEA. He has a strong background in multiscale modelling of climate and holds a PhD in Hydraulics Engineering. The main focus of his research is on global and regional scale climate variability and predictability, land-atmosphere interactions and atmospheric turbulence. He is currently coordinating the ENEA activities in the PNRR ICSC (National Research Centre for High Performance Computing, Big Data and Quantum Computing) Earth & Climate (Spoke 4) Research Program, aimed at developing a new generation of Earth System Models (ESMs). In recent years, he has been involved in several relevant international projects, including the Coupled Model Intercomparison Project phase 6 (CMIP6). Among other activities, he is contributing to the development of the European Community Earth System Model EC-Earth and serves as Associate Editor for the Journal of Applied Meteorology and Climatology.

### **Li Weiwei**

Li Weiwei, Ph.D., is a Senior Engineer at the Kunming Institute of Zoology, Chinese Academy of Sciences, and a Researcher specializing in popular science education in natural scientific research. With an International Curator Certificate, she serves as the head of the Yunnan International Joint Center of Urban Biodiversity. As a CAS “Light of West

China” Program scholar and a Young Talent of the Yunnan Revitalization Talent Support Program her research focuses on biodiversity conservation and sustainable utilization, green control of invasive alien species, rapid species identification, and public science education. She has received more than 10 provincial and ministerial awards and honors, including the Yunnan Provincial Science and Technology Progress Award, the National Advanced Worker in Science Popularization, and the Yunnan Provincial Science and Technology Popularization Award for Individuals. She has presided over more than 10 projects at the provincial and ministerial levels, authored 7 books, published over 30 academic papers and over 100 popular science articles, and obtained more than 40 authorized patents. The public science education cases she planned and curated have been successfully selected by the United Nations, COP15, and the Erhai Forum.

### **Ferdinando Boero**

Ferdinando Boero’s research focuses on marine biodiversity, ecosystem functioning, and sustainability. He has authored hundreds of scientific articles and policy documents for institutions such as the European Commission, FAO, the European Marine Board, the European Academies Science Advisory Council, and the G7. Over his career, he has led numerous national and international projects and contributed as a partner to many others. Formerly a full professor at the University of Naples Federico II, he currently serves as Chair of the Anton Dohrn Zoological Station, President of the Dohrn Foundation, Senior Associate at CNR-IAS, Vice President of Marevivo, and a member of the scientific councils of Pro Natura and WWF-Italy. His work has been recognized with prestigious awards, including the Albert I Medal for Oceanography from the Institut Océanographique de Paris, the Golden Trident, and the Medal for Physical and Natural Sciences from the Italian National Academy of Sciences. In addition to his scientific contributions, he has written popular science books exploring topics such as beauty, religion, economy, and even dog’s urinary behavior.

### **Hu Xiaojing**

Hu Xiaojing is a Deputy Director of Science and Technology Service Center of Sichuan Energy Internet Research Institute in Tsinghua, mainly responsible for international cooperation, achievement transfer and transformation, and cultivation of large, medium and small enterprises.

In terms of international cooperation, he led the team to successfully hold the 5<sup>th</sup> Energy Internet International Innovation Summit and the Global Green Hydrogen Scenery Summit and invited foreign dignitaries and academic leaders such as Cyrus Habib, Vice Governor

of Washington State, Mary Linster, Vice Dean of Washington University, and Steven Chu, former US Secretary of Energy (Nobel Prize winner). It has expanded cooperation with more than 30 countries and regions, including Britain, Canada, Chile and the United States, and promoted diversification of resources and expansion of market opportunities. Discuss the construction of ecological platform with international institutions such as British CodeBase incubator, build an international cooperation ecosystem of resource sharing, and promote the incubation of innovative projects.

Cooperate with universities such as Leeds University and Macau University to accelerate the transformation of scientific and technological achievements into productive forces and promote industrial upgrading. Cooperate with energy companies such as Italy Eni Group to jointly explore new energy technologies and business models and strengthen global influence and resource integration capabilities. In terms of building a scientific system, we have benchmarked the international advanced standards, integrated the experience of the Fraunhofer Association of Germany and the Taiwan Institute of Technology, and completed reports such as “Innovation Drives the High-quality Development of the Energy Internet Industry” and “Exploration on the Differentiated Development Path of Technology-based Vertical Incubators”. Since the establishment of the research institute, more than 20 enterprises have been incubated, among which Yichong Semiconductor Company has a valuation of 3 billion. In terms of industry research, we have a deep understanding of the development trend of the industry and completed research reports such as Global Hydrogen Energy Development Report, Suggestions on Developing Key Equipment Industry of New Power System in Chengdu, Investigation of Photovoltaic Industry Status and Analysis of High-quality Development Prospect.

### **Alberto Basset**

Alberto Basset is full professor of ecology at the University of Salento. His main research interests are on the organization and maintenance of biodiversity, ecosystem functions and services. He has produced more than 200 scientific publications, being recognized as one of the twenty top scientists for his scientific production on *ecosystem ecology*. Alberto Basset has been president of the Italian Society of Ecology, president and current general secretary of the European Ecological Federation, president of the Italian research networks on transitional water ecosystems (LaguNet) and of the Euro-Mediterranean lagoon Federation. He is member of the Executive Board and delegate in the General Assembly of the European e-Science Infrastructure on Biodiversity and Ecosystems Research (LifeWatch ERIC), member of the Advisory Committee of the Research Infrastructure EMSO ERIC and representative of the University of Salento in the Assembly General of the Italian branch of the European Long Term Ecological Research Infrastructure (eLTER RI).

## FORUM 4

### **Giulio Fancello**

Giulio Fancello (b. February 12, 1972, Sassari, Italy) is an expert in civil protection and early warning systems, currently serving as Head of the National Early Warning System Office at the Italian Civil Protection Department, Presidency of the Council of Ministers. Since June 2023, he has overseen the national alert system for meteorological, hydrological, and hydraulic risks. His responsibilities include the issuance of national bulletins and warnings, 24/7 operational monitoring and surveillance, and the coordination of the national radar and hydro-pluviometric networks. He also serves as Italy's National Focal Point for the Copernicus Emergency Management Service (CEMS).

From 2016 to 2023, Mr. Fancello headed the Regional Early Warning System and Civil Protection Contingency Planning Office at the Regional Agency for Civil Protection in Lazio. In this role, he managed over 230 monitoring stations and led the development and implementation of contingency plans for floods, tsunamis, avalanches, forest fires, and seismic events. Throughout his career, he has demonstrated a deep commitment to advancing integrated risk forecasting and emergency preparedness at both regional and national levels.

### **Zhou Gongdan**

Zhou Gongdan Professor of the Institute of Mountain Hazards and Environment, Chinese Academy of Sciences (CAS); Secretary-general of the Sino-Italian Joint Laboratory on Geological and Hydrological Hazards, the Alliance of International Science Organization on Disaster Risk Reduction, and the Committee of Landslide and Debris Flow Prevention and Control of Chinese Society of Soil and Water Conservation. Dr. ZHOU has been focusing on the research of dynamics of mountain hazards and the nonequilibrium state of granular matter. He has published more than 100 academic papers and authorized 16 Chinese invention patents; received the Awardee of "IAG/AIG GRANTS for Young Geomorphologists", and was selected by the National "Ten Thousand Talents Plan" and awarded the Outstanding Scientific and Technological Achievement Award of the Chinese Academy of Sciences in 2020.

### **Luca Guerrieri**

Senior Technologist at ISPRA, Geological Survey of Italy, where he works since 2000. Ph.D. in Geological Sciences, Sapienza University, Roma.

Researcher in active tectonics, Quaternary geology, and paleoseismology.

At international level, he has participated in numerous EU-funded research projects in various geological domains, he has contributed to two NSF-funded projects in Quaternary geology and paleoseismology.

He has represented ISPRA in international organizations (IAEA, UNESCO) and global and European programs dealing with Earth observation (GEOSS and Copernicus).

Since 2012, he has served as Italy's National Delegate in EuroGeoSurveys, an organization comprising 37 National Geological Surveys in Europe. In this role, he has promoted cooperation projects with non-European geological services (USA, China, and Israel).

Since 2023, scientific coordinator of the PNRR "GeoSciences IR" project, funded by the Italian Ministry of University and Research, aiming at building a research infrastructure for Italian Regional Geological Surveys.

Author of over 60 scientific articles published in peer-reviewed journals.

### **Su Li-jun**

Su Li-jun PhD and Professor of Geotechnical Engineering, is Deputy Director General of Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, Secretary General of China Committee of International Centre for Integrated Mountain Development, and Director General of China-Pakistan joint Research Center on Earth Sciences. He has more than 15 years' experience in research and teaching in geotechnical engineering. His research interests include constitutive modeling of geomaterials, numerical analysis of geotechnical problems, laboratory and physical model tests, geophysical investigation on underground conditions, and mechanism and mitigation of landslides. He developed a constitutive model for soft rock that can simulate the strain-softening and stress-pore pressure coupling effects. He conducted numerous pull-out tests of soil nails to investigate the mechanism of a soil nail in stabilizing slopes. He is currently working on the mechanism, hazard risk analysis and mitigation measures of landslides-granular flow or rock and ice debris flow under the support of several national research funds. He developed a rainfall infiltration model considering preferential flow in debris slope. This model overcame the difficulty of the current seepage model in simulating deep-seated landslides. He generated the geological structure and underground water condition of a deep-seated landslide using multiple geophysical methods. He is currently a board member of International Consortium on Landslides, vice chairman of the branch for Engineering Geology and Mechanics of the China Society for Rock Mechanics and Engineering, and editorial members for multiple international journals. He has acquired 2 key research projects from the National Natural Science Foundation of China, 1 project for the National Key Research and Development Program of China, 1 project for the Strategic Priority Research

Program of Chinese Academy of Sciences, and other key projects from national and local government of China. His research outcomes have been applied to the risk assessment for landslide hazards in Tibetan Plateau and its surrounding areas. He has published more than 140 papers in top journals and international conferences. He had been awarded the Outstanding Science and Technology Achievement Prize of Chinese Academy of Sciences.

### **Ye Jiaolong**

Ye Jiaolong is the manager of the Department of Science and Technology, working at the Institute of Nuclear Geological Survey, Sichuan Province, China. She mainly engages in the research of Remote sensing technology, geological disaster survey and management, and resource sustainable growth. She is involved in research and engagement with both local and international partners and networks. She has undertaken more than 15 national, and local projects, 1 APEC fund project, participated in the compilation of industry standards, and hosted the “Talent Introduction Demonstration Base” Chengdu, and is committed to scientific cooperation and innovation based on industry technology. She also develops research proposals and applies for research grants.

In the work of disaster investigation and prevention, she puts focus on application of new technologies and methods and takes the advantages of UAV aerial survey and remote sensing interpretation to actively serve the emergency rescue and rescue of geological disasters. During the implementation of disaster survey and management which will help to foster interactions and links both within the public and private sectors.

She works on identifying enabling technologies and policy tools which will help the engineers to improve their technical service abilities. In the field of cooperation, she undertook various administrative duties, attending and contributing to professional conferences and seminars both in China and abroad, establishing and developing partnerships with different institutions, Businesses, local agencies, academic institutions, and local government. In addition, her work includes the fields of landuse planning, ecological restoration, sustainable development and etc.

## **FORUM 5**

### **Sergio Cavalieri**

Sergio Cavalieri is Rector of the University of Bergamo. Full Professor of Operations Management, he works on topics concerning the innovation of management processes in industrial and service companies. He is past president of the U4I Foundation (University

for Innovation), past president of the Italian scientific association AIDI, coordinator of the Working Group of the 2021-2027 National Research Plan on Innovation for the Manufacturing Industry, director of the Executive Master in Industrial Asset Management, member of the international scientific associations IFAC-TC 5.1 on Advanced Manufacturing Technology and of IFIP WG 5.7 on Advances in Production Management Systems.

### **Edoardo Bemporad**

Edoardo Bemporad graduated in Nuclear Engineering, Ph.D. in Materials Engineering. Full Professor at the Department of Mechanical and Industrial Engineering, University “Roma Tre”, Head of the Materials Science and Technology group and Coordinator of several research national and international projects focused on advanced methods for microstructural characterization and modelling of advanced interfaces and multi-layer nanostructured coatings, thick and thin, for either anti-wear or anti-corrosion applications. Forensic Expert on materials engineering. Since 2018 he is a Consultant of the Italian Ministry of University and Research for EC Structural Funds and National Recovery and Resilience Plan. In 2024 he became member of the EC Technology Council for advanced Materials, Italian high-level representative. In the same year he was appointed Director of the Institute of Polymers, Composite and Biomaterials at CNR. Author of more than 134 papers and refereed conference proceedings with an h-index of 35 and more than 3500 citations.

### **Wang Wei**

Wang Wei is the Vice President of Beijing University of Technology. Doctor of engineering, professor. He has served as executive vice president of Beijing Institute of Technology, executive vice president of Yangtze River Delta Research Institute and assistant to the president of Beijing Institute of Technology. He is currently the Standing Committee Member and Vice President of the Party Committee of Beijing University of Technology. His main research interests are mechanical and electronic engineering, science and technology management and Industry-University-Research. He was awarded the China Industry-University-Research Promotion Award, the Advanced Individual Award, the third prize of ministerial-level scientific and technological progress, and so on. He was an excellent instructor of the 6<sup>th</sup> China International “internet plus” University Student Innovation and Entrepreneurship Competition and was selected as the torchbearer of the 19<sup>th</sup> Asian Games in Hangzhou in 2023.

## **Gianluca D'Urso**

Gianluca D'Urso is a Full Professor in the field of Manufacturing Technologies and Systems at Department of Management, Information and Production Engineering of the University of Bergamo. He currently holds several positions, including: Director of the Department of Management, Information and Production Engineering, Rector's Delegate for Applied Research, President of the Scientific Technical Committee of the Intellimech Consortium and Member of the Faculty Board of the Ph.D. School in Technology, Innovation and Management (TIM).

His main research topics focus on both conventional and non-conventional manufacturing technologies. Specifically, they include: additive manufacturing, micro-manufacturing, friction stir processing, FEM and Discrete Event Simulation Techniques applied to manufacturing processes

He has participated in numerous national and international research projects and has authored over 100 international scientific publications.

## **Jinqing Yu**

Jinqing Yu is a professor and doctoral supervisor at Hunan University, and the deputy director of Yuelushan Center for Industrial Innovation. Dr. Jinqing Yu graduated from University of Electronic Science and Technology of China (UESTC)/Research Center of Laser Fusion CAEP/Imperial College London and was a postdoctoral researcher at the University of California, San Diego and Peking University. He presided over 10 scientific research projects such as the National Natural Science Foundation of China and the Distinguished Young Scholars of Hunan Province. His research interests include laser-plasma interaction physics, ultra-short ultra-strong laser pulses interacting with plasma to generate high-energy particle beams, and laser generation of intense radiation sources and applications. He has made a series of progress in the fields of novel particle acceleration and radiation, laser terahertz sources, computational physics, etc. He has published over 60 research papers in authoritative journals such as PRL, APL and PPCF.

## **Bruno Siciliano**

Bruno Siciliano is professor of robotics and control at the University of Naples Federico II. He is also Honorary Professor at the University of Óbuda where he holds the Kálmán Chair. His research interests include manipulation and control, human-robot cooperation, and service robotics. Fellow of the scientific societies IEEE, ASME, IFAC, AAIA, AIIA, he received numerous international prizes and awards, including the recent 2024 IEEE

Robotics and Automation Pioneer Award. He was President of the IEEE Robotics and Automation Society from 2008 to 2009. He has delivered more than 150 keynotes and has published more than 300 papers and 7 books. His book “Robotics” is among the most adopted academic texts worldwide, while his edited volume “Springer Handbook of Robotics” received the highest recognition for scientific publishing: the 2008 PROSE Award for Excellence in Physical Sciences & Mathematics. His team has received more than 25 million Euro funding in the last 15 years from competitive European research projects, including two ERC grants.

### **Daniela Passariello**

Daniela Passariello is the Communications Manager at PRISMA Lab in the Department of Electrical Engineering and Information Technology of the University of Naples Federico II. She received the Master’s degree in Political Sciences and a postgraduate Master’s degree in Public Relations. Among her activities, she writes as a co-author of popular science articles on robotics.

### **Liu Chaohui**

Liu Chaohui received the B.E. from North University of China, M.E from Beihang University, and Ph.D. in the Electrical Machines and Drives (EMD) Research Group from the University of Sheffield, UK in 2006, 2011 and 2017 respectively.

From 2017 to 2020, he was with the Department of Research, Design and Development, Dyson Technology Limited, UK, where he was appointed an Advanced Engineer in 2017 and Senior Engineer in 2018.

He is currently a Principal Engineer and the Head of E-Powertrain at National New Energy Vehicle Technology Innovation Center (NEVC), Beijing, China. He is the Joint-director of Sheffield NEVC Electric Powertrain Research Centre (SNEPC). His research interests include machine drive, EV inverter, advanced control strategy, power converters, electric vehicle battery charger, wide band-gap device packaging and power module applications.

### **Alessandro Simeone**

Alessandro Simeone obtained his Ph.D. in Production Technology and Systems from the University of Naples Federico II in 2013, specializing in multi-sensor monitoring of turning processes. He then worked as a researcher at Loughborough University (UK), focusing on the development of decision-support systems to enhance industrial sustainability. In 2017, he became an Associate Professor at Shantou University (China), where his research centered

on the integration of smart manufacturing technologies and sustainability. In 2021, he joined Politecnico di Torino as an Assistant Professor in the Department of Management and Production Engineering, and in 2024, he was promoted to Associate Professor. His research focuses on sustainable production processes and systems. From 2015 to 2021, he was an affiliated researcher at the International Academy for Production Engineering (CIRP).

### **Yuchen Fan**

Yuchen Fan is a PhD student at Politecnico di Torino since 2023, specializing in Inclusive Manufacturing and Industry 5.0. Her research focuses on human-robot collaboration, cognitive load assessment, and intelligent assistance in manufacturing. She has a strong background in production management, data analysis, robotics, computer vision, and software programming. She obtained her Master's degree in Mechanical Engineering from Shantou University in 2023 and a Bachelor's degree in Electrical and Electronics Engineering from Zhejiang University City College in 2020. She has contributed to multiple research projects and international conferences, publishing work on deep learning-based process monitoring and human-robot collaboration.

### **Dario Antonelli**

Dario Antonelli, born in Torino, Italy on July 7, 1966, is an Italian Associate Professor at the Politecnico di Torino. He specializes in the scientific sector ING-IND16 - Technology and production systems. He has held this position since 2001. Before that, he was Researcher at Fiat Research Center from 1991-1992. He was also Assistant Professor at the Politecnico di Torino from 1992-2001. He has led several research projects, including the EU-FP7 project ECHORD-FREE and POS-FER projects like AMICO, ADIUVARE, and @CARE. These projects focused on developing support systems for collaborative human-robot assembly cells and assisting human spot welding workstations through Augmented Reality. He also teaches master and professional master courses such as "Production Systems", "Manufacturing Technology", "Simulation of Metalworking Processes", and "Automation".

### **Paolo C. Priarone**

Paolo C. Priarone obtained an MSc degree *cum laude* in Mechanical Engineering and a PhD in Production Systems and Industrial Design from Politecnico di Torino. He is currently an Associate Professor of Manufacturing at the Department of Management and Production Engineering at Politecnico di Torino and an Associate Member of the International Academy

for Production Engineering (CIRP). His research focuses on sustainable manufacturing and development, advanced production technologies, manufacturing system optimization and decarbonization, and the machining of difficult-to-cut materials.

### **Luca Settineri**

Luca Settineri is a Full Professor of Manufacturing Technologies and Systems at Politecnico di Torino and currently serves as President of AITEM (Italian Association of Manufacturing Technologies). He obtained his degree in Mechanical Engineering from the University of Palermo in 1988 and a Ph.D. in Production Engineering in 1994. He has held research positions at CNR, the University of Michigan, and the University of Stuttgart. Since 2000, he has been a faculty member at Politecnico di Torino, focusing on advanced manufacturing, machining processes, and sustainability. He has coordinated multiple research projects and contributed to international collaborations. He is an active member of CIRP and serves on editorial boards of manufacturing-related journals. His research covers process optimization, sustainable production, and additive manufacturing.

### **Li Shiyang**

Li Shiyang Associate Professor and Master's Supervisor, School of Environment and Chemistry, Shanghai University. He began pursuing his Ph.D. degree at the School of Municipal and Environmental Engineering, Harbin Institute of Technology in 2010. From 2012 to 2017, he conducted joint Ph.D. and postdoctoral research at the University of Illinois at Urbana-Champaign (UIUC), USA. Upon returning to China in 2018, he has worked at Tongji University and subsequently at the School of Environment and Chemical Engineering, Shanghai University, up to the present. His current research focuses include developing functional micro/nanofiber materials and conducting research on remediation engineering technologies for micro-pollution in natural water bodies, developing nano-water-absorbing materials and conducting research on environmental control technologies for advanced manufacturing. In recent years, he has presided over 3 national-level research projects and 5 provincial and ministerial-level projects and won the second prize of a provincial and ministerial-level science and technology award (ranked 1/15). He has published 26 papers in internationally renowned core journals, obtained 7 invention patents, and been invited to present academic reports at international conferences 4 times.

## FORUM 6

### **Roberto Danovaro**

Roberto Danovaro is Full Professor at the Polytechnic University of Marche, where he covered the position of Director of the Department of Marine Sciences of the Department of Life and Environmental Sciences (2004 to 2014) and Pro-Rector (Delegated to the Research). President of the Stazione Zoologica Anton Dohrn (National Institute of Marine Biology Ecology and Biotechnology) from 2013 to 2022. President of several Scientific International Councils and advisory boards. Coordinator of several EU and international projects. Past-President of the Italian Society of Ecology, of the Italian Society of Limnology and Oceanography and of the European Federation of Scientific Technological Societies. Currently is Member of the Academia Europaea (European Science Academy) and of the EU Academy of Sciences. Editor in Chief of Marine Ecology (Wiley) and Chemistry and Ecology (Taylor and Francis). RD received the World Prize BMC Biology, Award of French Society of Oceanography, ENI Award “Protection of the Environment” (2013) the Prize “Motumundi” for the Protection of the Environment and Climate (2024). Recognised by Expertscape as the top World Scientist in the Category “Ocean and Seas” for the decade 2010-2020.

### **Xiaojun Yan**

Xiaojun Yan, Director of National Technology Research Center of Marine Equipped Aquaculture, PhD in marine biology. Academician of the International Eurasian Academy of Sciences, National Leading Scientist of Ministry of Science and Technology. Director board member of Chinese Society of Oceanology and Limnology, Education board member of Marine Sciences of Ministry of Education. Dr. Yan has been working on research topics of nutrition, biochemistry and functional genes in the field of marine aquaculture for decades, recently focusing on the technology development for far-coastal mariculture. He has published more than 300 SCI cited research papers, 6 books and 90 patents. He has been named in the world's top 2% of Scientists List (career-long achievement), as well as Elsevier Chinese highly cited scientist in the field of Fisheries Sciences, he has been awarded medals of National Technology Progress Prize, Chinese Young Scholar Prize, National Labour Awards.

### **Antonio Terlizzi**

Born in Naples, Italy, 1968. Degree cum laudae in Biology, 1992. Phd in Ecology. His research activity focuses on marine diversity at different levels of biological hierarchy and on the quantification of spatial and distributional patterns of species, species assemblages and

habitats, mostly in relation to human impacts and mitigation interventions. He is actively involved, often as project/task leader, in national and international research programs and consultancies for environmental impact assessment and monitoring. From 2012 to 2016 he was assigned by the Rector of the University of Salento, to the University committee for the Research. Since 2016 he has been leading the Marine Biology lab at the DSV, University of Trieste, where he also acted as delegate of the Director for research and coordinate the PhD program in Environment and Life. In 2015 and in 2020 he has been selected by the ANVUR as a member of Groups of Experts of Evaluation (GEV 5 - Biology) in the national research assessment exercise (VQR 2011-2014, 2014-2019). To date, he is a member, with the role of President, of the Commission for National Scientific Qualification, Sector: 05/B1 – Zoology and Anthropology. Currently he is Full Professor in Zoology and Marine Biology at the Department of Life Sciences (DSV), University of Trieste, Italy and Director of the EMI Department at the Stazione Zoologica, Naples, Italy

### **Li Huaqiong**

Li Huaqiong is a Principal Investigator at Wenzhou Institute, University of Chinese Academy of Science (WIUCAS). Before he joined in WIUCAS in 2015, he worked in Singapore for two years after completing his PhD study in Nanyang Technological University. His current research interests are biomaterials and nanomedicine. In particular, he has been focused on development of advanced biomaterials to guide cell behaviour and then applied to the field of tissue engineering and regenerative medicine; construction of nanodrug delivery platforms for cancer and other diseases. He received more than 11 grants at the national, provincial, and municipal levels (with a total of 11 million RMB). He is also the coinventor of 4 filed patents. He has published over 60 journal papers, which have total Google Scholar Citations of over 34000 till April 2025. He has been awarded Outstanding Reviewer Awards 2021 & 2019 of Journal of Nanobiotechnology.

### **Isabella Buttino**

Isabella Buttino is Senior Researcher at the Istituto Superiore per la Protezione e la Ricerca Ambientale and coordinates the *Functional Biology and Plankton Genomic Lab.* and the Sino-Italian Lab. *Functional Biology of Marine Biota.* Associated with prestigious research centres, such as the Stazione Zoologica Anton Dohrn, where she began her scientific career as a marine biologist, and the National Institute of Oceanography and Experimental Geophysics, she is guest professor at Zhejiang Ocean University since 2012. The main scientific focus is the study of the biology and genomic of marine plankton, which is at the base of ocean life, in relation to environmental and anthropic pressures. Based on the

results of her research, the most representative organisms of marine zooplankton have been included in standardized protocols and are considered as model organisms for assessing the quality of ecosystems and marine contaminated matrices (water and dredged sediments). She is co-author of more than 100 scientific publications, including books and monographs, coordinator of Italian and European research projects, tutor and reviewers of PhD students at the national and international University.

### **Wang Zheng**

Wang Zheng is an associate professor at the Institute of Oceanology, Chinese Academy of Sciences. His main research direction is the nonlinear variability and dynamic mechanism of the ocean circulation, the material and energy transport and interaction between the west boundary current of the western Pacific and the Indonesian Seas, the distribution of microplastics in the Indonesian Sea and their impact on the ecological environment, etc. As the principal investigator and a key member, he has successively undertaken the 973 projects, the National Natural Science Foundation of China project, the Strategic Priority Research Program of the Chinese Academy of Sciences, the Asian Cooperation Fund project of the Ministry of Foreign Affairs, the Alliance of National and International Science Organizations for the Belt and Road Regions (ANSO) Science Projects, etc. He has published more than 30 academic papers and won three provincial and ministerial-level awards. He has served as the chief scientist for 7 Sino-Indonesian joint cruises and is currently serving as the executive director of the Sino-Indonesian Joint Laboratory of Marine Science (SIMS).

## **FORUM 7**

### **Carlo Barbante**

Carlo Barbante is a professor at the University of Venice, founder and former director of the Institute of Polar Sciences of the National Research Council (CNR). He has been working for years on climate and environmental reconstructions and the development of innovative analytical methodologies in the environmental and biological fields. He has participated in numerous expeditions and sampling campaigns in polar areas and the Alps and is the coordinator of national and international research projects, as well as the author of over 330 publications in high-impact scientific journals. He has been awarded a prestigious Advanced Grant from the European Research Council for the study of anthropogenic impact on climate in pre-industrial times. He is an elected member and vice-president of

the Academy of Sciences known as the XL and Secretary of the Science Class of the Veneto Institute of Sciences, Letters and Arts.

### **Cui Yingchun**

Cui Yingchun is the PI of the polar geology of the Polar Research Institute of China. He received his PhD in Marine Geology in 2008 from Institute of Oceanography, Chinese Academy of Sciences. His research focuses on the geology and geophysics of the polar region using seismic and traditional geological methods integrated with sediment cores to study the regional geological evolution, paleoclimate, paleoenvironment, and paleoceanography. The main goal of his projects is to provide data to compile geological maps and reconstruct the past change of the earth. Presently He is the member of the Marine Surveying, Mapping and Geographic Information Branch of China Ocean Engineering Consulting Association, and the National Representative of Geoscience Scientific Group of SCAR (Scientific Committee for Antarctic Research).

### **Andreas Laufer**

Andreas Laufer is a structural geologist at the Federal Institute for Geosciences and Natural Resources (BGR) in Hannover, Germany, where he leads the Polar Geology Unit. He holds a geology diploma and a doctorate from the University of Tübingen, and has held a teaching position at Goethe University Frankfurt. Dr. Laufer has taken part in 11 land-based research missions to Antarctica, including work on the ANDRILL project, and has also joined expeditions to the Arctic as the team leader. His research focuses on geodynamic processes within the Earth system and the interplay between the lithosphere and cryosphere in the polar regions, spanning from deep geological history to the present.

### **Liu Chenguang**

Liu Chenguang is a scientist working at the First Institute of Oceanography under the Ministry of Natural Resources (MNR) of China, situated in Qingdao. He is affiliated with the Key Laboratory of Marine Geology and Metallogeny at the institute, and also associated with the Laboratory for Marine Geology within the Pilot National Laboratory for Marine Science and Technology (Qingdao).

## **Ma Lijie**

Ma Lijie is an Associate Professor at the Institute of Oceanology, Chinese Academy of Sciences, affiliated with the Key Laboratory of Marine Geology and Environment in Qingdao. She holds a PhD in Marine Geology and focuses on coastal and island geological hazards, sediment transport, marine methane processes, and the environmental effects of island development. She has led several national research projects in these areas.

## **Silvano Onofri**

President of the National Scientific Commission for Antarctica, former Full Professor of Systematic Botany – University of Tuscia –, he contributed to the design and foundation of the Botanical Garden of Tuscia and the Natural Reserve of Monte Casoli di Bomarzo; he founded the Collection of Fungal Cultures from Extreme Environments of the National Museum of Antarctica. He has published dozens of species and 25 genera of fungi, new to science. As part of the PNRA (National Research Program in Antarctica), he participated in six Antarctic expeditions and one in the Arctic. PI of the ESA-LIFE Program, on the International Space Station, which demonstrated that Antarctic black microfungi could survive in Space and on Mars. With the BIOMEX and BIOSIGN projects (International Space Station, ESA), a library of biosignatures is being created, for the search for life on Mars and beyond. Consultant to ESA and NASA for the Mars Sample Return Project, and for the assessment of the impact of lunar exploration, and directed the National Astrobiology Project of the Italian Space Agency and the Space Synthetic Biology Topical Team of ESA. He received the Medal of Honor from the European Mycological Association.

The new fungal species *Naganishia onofrii*, *Antarctolichenia onofrii* and *Cystobasidium onofrii* are named after him. Author to date of 154 publications in international scientific journals with an H-index of 41 (Scopus), and of numerous volumes and chapters of international books.

## **Chen Jianfang**

Chen Jianfang received his B.S. in Geochemistry and M.S. in Environmental chemistry from Zhejiang University in 1990 and 1993, respectively, and his Ph.D. in Marine Geology from Tongji University in 2005. He is now the Deputy Director General in the Second Institute of Oceanography, Ministry of Natural Resources. He is also leader of marine ecosystem monitoring and forecasting team supported by Ministry of Science and Technology (MOST), member of ICES/PICES joint working group on Ocean Negative Carbon Emission (ONCE).

He has led and completed national scientific research projects such as key project of the National Science and Technology Support Program and key project of the National Natural Science Foundation of China. Currently, he is presiding over the Polar Basic Science Frontier Special Project of the national Natural Science Foundation of China, Zhejiang Province “Vanguard Plan” and other projects. He has published more than 150 papers in *GRL*, *L&O*, *PO*, *JGR*, *Science Bulletin* and other mainstream academic journals, including more than 50 papers as the first/corresponding author.

### **Giorgio Budillon**

Giorgio Budillon is a Full Professor of Oceanography, Meteorology and Climatology at the University of Naples “Parthenope”, where he also serves as Pro-Rector for Research and Institutional Relations.

As a physical oceanographer with a strong focus on fieldwork and observational studies, his research primarily revolves around ocean stratification, circulation, and mixing, as well as their roles in the Earth’s climate system. While much of his early scientific work concentrated on the Southern Ocean—particularly the Pacific Sector and the Ross Sea—he has also conducted extensive research in the warmer waters of the Mediterranean Sea since 1991.

In recent years, his interests have broadened to include the transfer of heat and freshwater within the ocean, as well as exchanges between the ocean, cryosphere, and atmosphere. His research encompasses stratified ocean bodies, interbasin exchanges, dense water formation, deep ocean ventilation, polynya dynamics, and sea-air-ice interactions. He has also investigated the use of weather radar measurements to detect and analyze intense precipitation events.

He currently serves as Vice President of the National Scientific Commission for Antarctica and is the national representative for the Southern Ocean Observing System. He is also a member of the Scientific Committee of the National Technological Cluster Blue Italian Growth and of the National PhD Program in Polar Sciences. Additionally, he holds the position of Vice President of CoNISMa, the Italian National Consortium of Marine Universities.

### **Pasquale Castagno**

Pasquale Castagno is an observational physical oceanographer with a special interest in the Southern Ocean and the Ross Sea. He is currently Associate Professor of Oceanography, Meteorology and Climatology at the University of Messina (Italy). He has participated with Italian and international teams in 12 oceanographic expeditions to the Southern Ocean

and Ross Sea, including as project PI on board and scientific coordinator in one of these expeditions.

Using various oceanographic data, his research focuses mainly on the processes involved in the formation of Antarctic Bottom Water (AABW), the temporal and spatial variability of the Dense Shelf Water (precursor of the AABW), and the role of climate anomalies that influence the thermohaline properties of these water masses.

He is also interested in the cross-shelf exchange between the Ross Sea continental shelf and the deep ocean, focusing on both the intrusion of the Circumpolar Deep Water into the continental shelf and the outflow of the AABW.

### **Yongqin Liu**

Yongqin Liu is a professor at the Institute of Tibetan Plateau Research, Chinese Academy of Sciences, and a leader at the Center for the Pan-Third Pole Environment, Lanzhou University. Her research focuses on glacier ecosystems and the interactions between microbial communities and their environments in high-altitude regions. Her work covers microbial ecology, including nitrogen cycling, carbon fixation, and viral dynamics in glacial habitats. Prof. Liu has contributed significantly to understanding how climate change impacts microbial processes and ecosystem stability in alpine environments. She has held various academic roles, including associate professor at the Institute of Tibetan Plateau Research, and visiting scholar at institutions such as the Max Planck Institute for Terrestrial Microbiology and the Max Planck Institute for Biogeochemistry. Prof. Liu has led multiple international research projects, including ecology investigations of Tibetan glaciers and lakes, and has been a team member of the Antarctic McMurdo Dry Valley LTER Program and Arctic NASA Exobiology Program. She has published extensively, with notable papers in *Nature Biotechnology*, *ISME Journal*, and *Science Bulletin*. Her research has been supported by several major grants, including from the National Natural Science Foundation of China and the Ministry of Science and Technology of China.

### **Mauro Mazzola**

Mauro Mazzola is an atmospheric physicist and researcher at the Institute of Polar Sciences of the National Research Council of Italy. He has dedicated a large part of his career to the study of polar regions. Since 2010, the Svalbard Islands have been his primary research field, where he has conducted numerous scientific campaigns to investigate the optical and physical properties of atmospheric aerosols. He also manages atmospheric measurements at the Climate Change Tower in Ny-Ålesund, Svalbard. In recent years, his research activities have also extended to Antarctica, where he is carrying out similar

studies to compare atmospheric processes in the two polar regions and to obtain a more complete understanding of global phenomena. Since 2020, he has held the role of head of the CNR's Arctic Station "Dirigibile Italia" in Ny-Ålesund and, in this capacity, coordinates the scientific and logistical activities of the station.

### **Gianluca Bianchi Fasani**

Gianluca Bianchi Fasani received a Degree in Applied Geology and a Ph. D. in Earth Sciences from Sapienza University of Rome. He's currently a Senior Researcher in the Agency for New Technologies, Energy and Sustainable Economic Development– Antarctic Technical Unit (ENEA-UTA). Has been for 7 years responsible of the Logistical Service in ENEA-UTA. Expedition Leader in Mario Zucchelli Station (7), Concordia Station (3) and onboard the RV Laura Bassi (1).

Responsible for the logistic aspect of the following European Projects: a) "Beyond Epica: Oldest Ice". A 1.5 million year look into the past for improving climate predictions. b) "Beyond Epica Oldest Ice Core: 1,5 Myr of greenhouse gas climate feedbacks" – Fighting and adapting to climate change - Addressing knowledge gaps in climate science, in support of IPCC reports.

Responsible for technical aspects of the "Gravel-runway project" in Boulder Clay (Antarctica).



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